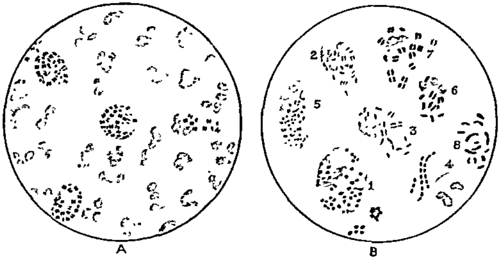
POST-GRADUATE SURGERY

VOLUME III



All represent drawings from gonorrhœal urethral smears, stained by Gram's method (Jensen's modification). Magnification, about 1000 diameters.

A. Shows pus cells containing intra-cellular gonococci, also some lying extra-cellularly. Note that they are Gram negative and kidney shaped.

B. This is a composite painting made up from various urethral smears to show the different varieties of secondary organisms which frequently occur in gonorrhœal pus, more especially in chronic cases. All these secondary organisms may occur within pus and epithelial cells, but more commonly they lie extra-cellularly. Nos. 1 to 6 are painted from the actual specimens. Nos. 7 and 8 are somewhat diagrammatic. Nos. 1, 2, 3 and 5 are the most common types found.

1. Pus cell showing *Staphylococcus albus*—Gram positive. Note that some are lying partially digested in vacuoles and have lost their Gram positive character.
2. Pus cell showing a diphtheroid bacillus (Xerosis type)—Gram positive.
3. Pus cell showing a short Gram positive *Diplobacillus* with pointed ends, indistinguishable morphologically from the *Pneumococcus*.
4. Shows a similar organism to No. 3, except that it occurs in chains, resembling a *Streptopneumococcus*.
5. Shows a small *Diplobacillus*—Gram negative. It assumes various shapes and coccoid forms; the latter are not kidney shaped but lanceolate.
6. Pus cell with a large Gram negative bacillus.
7. Shows the *Diplococcus magnus* of Rosenthal or *Pseudogonococcus*. It is weakly Gram negative, and is four times as large as the *Gonococcus*. It occurs rarely in the urethra, more commonly in conjunctivitis.
8. Shows a diphtheroid bacillus with clubbing and involution forms—Gram positive.

(*By courtesy of the Medical Research Committee, National Health Insurance, Special Report Series, No.* 19, 1918.)

(See Part XXXV, Section 1.)

POST-GRADUATE SURGERY

Edited by

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VOLUME III

With 1015 *Figures in the Text*

MEDICAL PUBLICATIONS LTD.
37 Bedford Square, London, W.C.1
1937

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MEDICAL ASPECTS OF SURGERY

by

R. SLEIGH JOHNSON

MEDICAL ASPECTS OF SURGERY

"Surgery is the strongest of all research weapons in the hands of the physician, and posterity, I fear, will not hold us guiltless of the sin of allowing hostility, or imperfect understanding, to grow up between physician and surgeon in this great creative period in the science and the art of medicine. How much more rapid our progress would have been, how much more accurate our labours, what waste of time and effort would have been spared, if, instead of living each inside his own impenetrable ring fence, the physician and surgeon had met on common ground *in the interest of the patient. Our only excuse, the only condonation,* is that the sin was not so much of our own creation as hereditary." (Moynihan, "Essays on Surgical Subjects.")

There *is little need at the present time to stress the interrelationship* and common aim of medicine and surgery. Every surgeon will agree that they are fundamentally inseparable, supplementary the one to the other, and but differing aspects of the same broad general study of disease. It follows, then, that each patient upon whom an operation is contemplated is to be regarded not merely as the possessor of a surgical lesion to be removed or remedied, but as an individual whose other systems merit investigation and assessment of their ability to withstand successfully the surgical measures proposed. It is in evaluation of this "surgical risk" and adoption, where available, of means whereby it may be diminished that the physician can most usefully serve his surgical colleague.

From a still broader standpoint, the risk in operating in a given case is dependent upon other factors besides the physical condition of the patient and the procedure to be carried out, namely, the surgical wisdom, competence and technique of the operator, and the surroundings and facilities under which the operation is to be performed. For the purpose of this survey, the latter factors may be accepted as adequate, and consideration be reserved for the former.

Again speaking generally, operations fall into three groups. In the *first*, the *indications for operation are absolute and beyond question*, as, for example, in perforated duodenal ulcer or strangulated gut, and whatever the patient's condition and circumstances surgery must be attempted as a life-saving measure. Here, *consideration of operative* risk is purely an academic question with no practical influence upon

procedure. The risks, however high, must be taken, in that those of abstension are yet higher or even hopeless.

The *second* group concerns *minor operations* done at a convenient time to surgeon and patient and upon a healthy subject, as, for example, the removal of a lipoma or similar localised condition. In this type the operative risk should be so slight as to be negligible, and therefore one hardly possible or necessary to assess.

It is with the *third or intermediate* group, involving all other cases, that the practical issue is concerned and decision made for or against operation.

This group includes the ordinary type of major operation, carried out not necessarily upon an otherwise fit subject, but in enforced association, perhaps, with other degenerative changes or disease conditions. The patient may, for example, be elderly, obese, or unfit from preceding illness. The choice may be between an operation, which, though desirable from the standpoint of final recovery, cannot be called essential to life and is certainly not free from risk, and, on the other hand, a continuance of medical treatment, with avoidance of immediate danger though with less complete benefit or relief than that afforded by operation if successfully withstood. The gall-bladder, for example, may frequently be the seat of such a choice. An error in judgment may mean an unnecessary death, however good the intention. A great responsibility falls, therefore, upon those charged with assessing the risk and advising as to operative interference.

The factors may now be considered which combine to make a given person either a good or a bad "surgical risk," the latter being defined as one in whom the chances of recovery from operative treatment of his condition fall well below the average.

A. Physiological Considerations

(1) *Age.* The added dangers of operation at the extremes of life are well recognised. Operations, for example, within the first few days of birth, as for congenital deformities, carry a heavy risk, although in later infancy these may be minimised by special care and preparation. Dehydration, hæmorrhage, alkalosis, acidosis, and liability to pulmonary complications are amongst the special dangers in childhood, the risks of these being proportionately greater after abdominal, and particularly intestinal, interference. Speed (but not *haste*) of surgical measures, maintenance of warmth during and after operation, free supply of body fluids and carbohydrates, and suitable choice of anæsthetic combine to keep mortality at a minimum. With regard to the last point, the

use in the main of nitrous oxide-oxygen inhalation, together with local analgesia when indicated, has been found the most useful combination.

Old age similarly has its dangers for surgery, although senile degeneration is to be estimated not so much from years as from objective vascular and other demonstrable changes. Liability to pulmonary events—bronchitis, hypostatic collapse and pneumonia—and to thrombosis of essential arteries is proportionately greater and will need appropriate prophylactic measures. Moreover, the anxieties of middle age, especially as regards continued wage-earning capacity in the hospital patient, are factors increasing surgical risk in the restlessness and economic worry apt to ensue.

The most favourable period for operation is then the intermediate decades, when physique and resistance are good, powers of recovery unimpaired and operative trauma well withstood.

(2) *Sex.* In general, women are better operative risks than men where major surgery is concerned. Liability to shock appears less and resistance to hæmorrhage greater, while pelvic operations in particular are more readily withstood. When possible, it is desirable to avoid the times of menstruation on account of associated metabolic and nervous disturbances. The changes associated with the menopause —nervous, vascular, and endocrine—necessarily carry some increase in general operative risk.

(3) *Physique and bodily conformity.* The unduly thin and the unduly fat are both poor candidates for surgery, the former from lack of nutritional reserve, the latter from mechanical difficulties and impaired resistance. Of the two the fat subject is the greater risk, especially with an abdominal operation. The wound is deep, access to structures restricted, tissues friable and slippery, and differentiation of organs more difficult. Operation-time is thereby prolonged. Fatty infiltration of the heart and pericardium diminishes cardiac reserve, and the added weight of the parietes and fulness of the abdomen hamper the diaphragm. Respiratory complications are correspondingly more frequent. The danger of fat embolism has to be considered; venous thrombosis is commoner; and among late sequelæ ventral hernia is a possibility.

Heavy muscular build may sometimes be a drawback and increase difficulty of approach, e.g. to the kidney, and the lighter, more wiry build is on the whole a lesser risk.

Where operation is not urgent, these risks may be diminished by appropriate dietary measures. The obese are encouraged to reduce weight, and the thin to build up nutrition before the chosen date.

(4) *Habits.* The added risks of the heavy drinker need no emphasis; repeated saturation with alcohol is responsible for his frequent resistance to anæsthetics, while obese build, cardio-vascular degeneration, and hepatic damage carry further dangers. Liability to delirium tremens in the post-operative phase is marked and affords good reason for continuing to give some alcohol throughout this period. The risk of hepatic inadequacy is lessened by the free administration of glucose. Prolonged anæsthesia and diminished resistance to bacterial infection make post-operative pneumonia a complication especially to be feared. Evidence of developed cirrhosis of the liver should be considered a bar to all but essential operations.

The heavy smoker has the scales weighed a little against him as regards irritability of the pharynx and upper respiratory passages and added liability to cough for some days after operation, and it is well for him to cease or at least reduce his smoking for a few days previously.

The drug addict as commonly understood, e.g. the chronic taker of morphia, cocaine or barbiturates, is a subject on whom to avoid operative measures whenever possible. Resistance to anæsthesia and susceptibility to infection and to major mental derangement are marked. When operation is essential, the usual supply of the drug must be continued throughout the period of illness.

(5) *Occupation and social status.* These are to some extent included in the previous considerations. Occupation involving regular exercise and good muscular tone clearly makes for a safer operative risk than the overfeeding of idleness or the coercion of habit and diet associated with particular occupations, such as that of publican, commercial traveller, or some walks of business life. Those subject to constant rush and tear and more than their quota of anxiety are not the best subjects for operation. The added concern when medical men are patients is more than a myth. With this are linked up factors of temperament and emotional type. The phlegmatic is the better risk, being less liable to shock; the apprehensive or nervous type, especially the true neurasthenic, is a poorer risk. He has less faith, less ability to rest and submit to treatment, approaches operation in a mental tumult and often desires in the post-operative stage to direct his own régime instead of leaving it to others. Major mental disturbance, especially of the maniacal form, is not very infrequent after operation in this type, though usually but temporary in duration.

No generalisation can fairly be made as regards racial factors, but these clearly come into consideration with those outlined above.

B. Factors of Previous or Associated Disease

Apart from physiological considerations in assessing chances of recovery from operation, the influence of previous illness or of accompanying defects in other organs or systems than that of the surgical lesion in question must naturally be considered. The effect on the surgical risk will, of course, vary with their nature and severity. *A complete examination will alone reveal such associated conditions*, especially if they be latent before operation, as with some pulmonary lesions. A convenient method of review of the main systems concerned will be on an anatomical basis:

(1) *Cardio-vascular disease.*

Of associated medical conditions, one of the chief to arouse doubt in the mind of the surgeon as to operability is the presence of known or suspected heart disease, although anxiety is frequently greater than need be. It is without question a sound procedure that every patient *prior to operation should be critically examined as to his cardio*vascular system, but limitation of this survey to the customary stethoscopic examination immediately before anæsthesia is of negligible value and is to be strongly condemned. To be of real help in decision, investigation must be made on a definite plan.

The patient is first interrogated for history of previous cardiac illness, and for symptoms pointing to myocardial weakness; of these the most important is inquiry for undue dyspnœa on exertion, with an estimate of the degree of effort needed to produce it, whether this be walking on the level, on an incline or upstairs, or only strenuous hurrying. *Alternatively, dyspnœa may be of nocturnal or "cardiac asthma"* type. In the same way, inquiry is made as to precordial or substernal pain, with its degree, if present, from tightness or discomfort to true anginal features. If the patient's condition allows, an estimate of exercise tolerance should be made to assess the cardiac reserve; if this be satisfactory, the pulse-rate should return to its resting level usually within one, and certainly within two, minutes.

On examination of the heart, the points to be noted are the size of the heart, the rate and rhythm, the presence of valvular lesions and the tone of the myocardium. The latter will be indicated by the force of the impulse, together with the length and pitch of the first sound at the apex. Signs of ill omen are a diffuse cardiac impulse and a short high-pitched or reduplicated first sound, with tic-tac or gallop rhythm. The need for accurate interpretation of cardiac murmurs, organic or

functional, need not be stressed. Estimation of the pulse and the condition of the arteries, and recording of the systolic and diastolic blood-pressure, should always be made. Cyanosis or distension of veins is noted, and search made of the extremities, lung bases and sacrum for œdema, and for signs of passive congestion of abdominal organs. Where the circumstances will allow, and especially where doubt is aroused by clinical examination, an electrocardiographic record and an orthodiagram or teleradiogram of the heart should be made. Evidence of myocardial damage, not patent on ordinary clinical tests, may by these means not infrequently be revealed, and warning be given against the advisability of operation.

With these data, and bearing in mind the nature of the operation proposed, the surgical risk may be reasonably assessed. For purposes of discussion, the following simple classification may be adopted :

(a) *Rheumatic heart disease.* Acute rheumatic carditis, as with any other actively toxic condition of the heart muscle, is a bar to operation involving general anæsthesia. Perhaps one of the most frequent errors is the too-early removal of tonsils, with recrudescence of endocarditis and joint inflammation. Chronic rheumatic heart disease, however, when well compensated and where the tone of the heart muscle is good, carries little if any added risk, especially in adolescence and early adult life. The mere presence of a valvular lesion need not be feared so long as the patient has no symptoms of undue dyspnœa or fatigue and shows no signs of congestive failure. An essential operation is never contra-indicated, and seldom one of choice, while selection of anæsthetic is not greatly affected. Where time allows, benefit may accrue from a preliminary period of rest in bed before operation, and where the patient is nervous on account of his heart simple sedatives will save the unnecessary work of the heart resulting from emotional tachycardia. There is no call for digitalis in the absence of failure. Similarly it is wise that convalescence should not be hastened. Of the slightly greater risks associated with rheumatic valvular lesions, in particular with mitral stenosis, perhaps the most important, though unavoidable when it occurs, is an added liability to post-operative embolism—arterial from blood clot in the left auricle, or venous from stagnation in the great veins. Pulmonary infection and hæmorrhagic infarction are also somewhat more common.

The presence of cardiac failure, however, radically alters the prognosis. Wherever possible, operation upon patients with cardiac œdema or gross signs of congestive failure should be avoided, or at

least delayed until the maximum of compensation is restored by adequate rest in bed and digitalisation.

Abnormalities of rhythm are of importance in this respect. Occasional premature beats may be disregarded in the absence of more definite contra-indications. Their occurrence during anæsthesia is in any event very common. Auricular fibrillation in rheumatic cases, if well controlled by digitalis and unaccompanied by failure, carries no great risk and should not deter from operation ; it is essential to give adequate preliminary treatment so as to bring the ventricular rate within normal limits. Auricular flutter likewise calls for preliminary digitalisation. Liability to attacks of paroxysmal tachycardia should be a warning feature, since a prolonged attack during or after operation might well be terminal. Attempt should be made, where the liability is known, to control or abolish the attacks by quinidine in the pre-operative period. The value of an electrocardiogram in interpreting such irregularities is clear.

(*b*) *Arteriosclerotic and degenerative heart disease.* In this wide group the risks of surgery are far greater. The patient is usually older, and there is fault with the vital myocardium rather than any mechanical valvular difficulty. Where examination points to a widespread degeneration of the heart muscle and presumptive interference with its own blood supply, any non-urgent or non-essential operation is to be avoided. Alternatively, where there is no other choice, special care and precautions are to be adopted. Decision is often made easier by the circumstance that many operations at this age are of the latter type, and the risks although great are legitimate.

Syphilitic heart disease with aortitis, aneurysm or aortic regurgitation, in contrast to the rheumatic group, is a bad risk. Sudden death, during or shortly after operation, is not uncommon, hence only essential surgery should be performed in such cases. Similarly, patients with angina pectoris, signs of coronary atheroma, or previous coronary infarction are undesirable subjects for elective surgery. The factors must be weighed of the urgency of operation against the degree of dyspnœa, fatigue or chest pain present. Some disorders of rhythm and action, such as heart block or pulsus alternans, indicate profound exhaustion of the heart muscle and diminished reserve, and the risk is then so great as to permit of imperative operation only. The presence of acute coronary disease (apt to be confused with some acute abdominal lesions such as cholecystitis) is an absolute bar to operation.

With regard to hypertension, a persistently raised diastolic pressure is of more adverse significance than a corresponding rise of systolic

the added rise of pressure produced. With nitrous oxide, cyanosis and venous congestion are to be avoided; with ether, so great a concentration as would irritate the respiratory passages.

Similar care is needed in the stage of recovery from operation. Mental rest and relief of pain are important in their reflection upon the heart's action. Convalescence must not be hastened, as it is usually found that the cardiac reserve is to some degree lessened by a major operation.

In assessing cardiac risk, the need must not be overlooked of simultaneous investigation of correlated systems, such as the renal or hepatic, for adequacy of function.

(2) *Respiratory affections.*

As with the heart, the respiratory tract can never safely be omitted from a review of operative risk. The question of pulmonary complications having already been considered in some detail (see Vol. II, page 2001), only a brief outline of the main factors concerned need be given.

Failure of recovery from operation through a respiratory disaster is most often brought about by the development of an intercurrent broncho-pneumonia; less often pulmonary suppuration is the cause, and occasionally a severe embolism. In some circumstances, the possibility of these dangers may be recognised beforehand from a knowledge of preceding or accompanying pulmonary disorder or other predisposing factors. These may lead to postponement or avoidance of non-urgent operation, or to adoption of special precautions in anæsthesia and post-operative conduct of the case. Factors adversely influencing surgical risk from the pulmonary aspect include the following:

(*a*) *Age.* There is a special liability in the very young and in the aged to bronchial and pulmonary infection. Maintenance of body warmth is the best safeguard.

(*b*) *Habitus.* Obesity is an added liability, in virtue of its mechanical burden upon respiration, with impaired mobility of the diaphragm and ineffectiveness of cough.

(*c*) *Previous respiratory affection.* No patient with a common cold or active bronchitis should be operated upon except in emergency. The risk is definite and neglect may be serious. Anæsthesia is less well borne, danger of downward spread of infection to the lungs not inconsiderable, and the strain of coughing may cause stitches to burst or hæmatomata to form, and in any case rest and recovery are impaired by the pain and discomfort produced. When operation is essential, irritant anæsthetics are to be avoided.

The patient with asthma and chronic bronchitis, usually with associated emphysema, should, where possible, be operated upon in the summer rather than the winter months to diminish the chances of superadded infection. Where feasible, preliminary respiratory exercises and massage, aimed at mobilising the thoracic cage and improving diaphragmatic excursion, will repay the patient in lessening his handicap and the risk of post-operative chest troubles. Severe emphysema may be an indication for local or spinal anæsthesia.

As regards operative technique, the insertion of additional supporting sutures in such subjects is a wise precaution, together with their retention for an added period to minimise the risk of their yielding from cough. Post-operative care will include the use of suitable stimulating expectorants and the avoidance of depressing drugs; atropine especially is of prophylactic and therapeutic value.

Reactivity of latent phthisis after operation is still a cause of disappointment, or worse, as regards the final result. Where suspicion is aroused from the previous history, skiagrams of the lungs will indicate need for suitable anæsthesia if operation is still desired. Inhalation anæsthesia may be replaced by basal narcosis or spinal analgesia, or irritant vapours at least avoided. Similar precautions will be required in the presence of chronic non-tuberculous lung disease, such as pulmonary fibrosis or bronchiectasis, where this complicates, say, an abdominal case.

(*d*) *Nature of proposed operation.* The nearer the site of operation to the diaphragm, as with a high abdominal section, the greater the risk of pulmonary sequelæ from trauma and inhibition of its movement. Thus pulmonary collapse and broncho-pneumonia occur most frequently after such operations as cholecystectomy or gastrectomy. The need is evident, therefore, for avoidance of unnecessary bruising or stretching of tissues, and for promoting free basal expansion in the post-operative stage. In this respect carbon dioxide is the most valuable stimulant to respiration available, while mechanical restraint from bandaging must be minimised.

(*e*) *Aspiration of infective material.* Inhalation of contaminated secretions under anæsthesia is the chief cause of post-operative abscess of the lung, and a contributory cause of broncho-pneumonia. Any obviously septic lesion in the mouth or throat, such as infected teeth or tonsils, should, wherever possible, receive attention and be eradicated before a major operation is performed. When the operation field is itself in the region of the upper respiratory tract, blood or infective material must be prevented from entering the bronchi by means of

suitable posture of the patient, and by the adaptation of anæsthesia to include removal of all local secretions by mechanical suction.

The above considerations apply to the risks of general surgery from thoracic complications. A review of the subject would be incomplete without mentioning another aspect, namely, the question of operative risk as applied to thoracic surgery itself. Perhaps this generalisation may be allowed—that if thoracic surgery is to make its legitimate progress and to keep pace, say, with the advances of abdominal surgery, then risks must be expected and braved in this developing stage of its history. The possibilities of surgery have recently been directed to a number of formerly incurable medical conditions of the chest, such as unilateral bronchiectasis or fibrotic phthisis with persistent cavitation, and some cases of pulmonary new growth, and by well-designed thoracoplastic or lobectomy operations dramatic cures have ensued. In such established states the outlook from medical treatment is so poor and life so restricted that it is justifiable to take the risk, assuming that the case conforms to certain requirements. It is reasonable, moreover, to expect that with further advances in surgical and anæsthetic technique these risks, now admittedly great in many instances, will be progressively lessened. Such aids as the oxygen-tent are already not without effect.

Medicine and surgery in chest diseases are rapidly becoming more and more complementary to one another. Thoracoscopy, division of adhesions, bronchoscopic diagnosis and therapy, adaptations of technique for empyema treatment, all instance the close interrelation of medicine and surgery in this sphere.

C. Risk from the Renal Aspect

Turning attention from the chest to the abdomen, the state of the kidneys as regards functional efficiency must pass the surgeon's survey, both from the general aspect and more particularly where a genito-urinary operation is contemplated. The simplest observations, nevertheless of great value, are made from a careful examination of the urine, noting especially the amount passed, specific gravity, and presence of albumen, pus cells, red blood cells or casts. This examination, which should be an invariable routine before any operation, would at once exclude from the danger of elective surgery cases of active nephritis or gross urinary infection.

In gross renal disease the operative risk is high, and the means available to reduce it are but meagre. In acute nephritis any operative procedure is undesirable, since the degree of renal damage is thereby

sure to be further increased. A word of caution is needed here, as with acute rheumatic infection, against the too hasty removal of tonsils after acute inflammation, or a vigorous or extensive eradication of septic foci, dental or otherwise, procedures liable to be followed by diffuse or focal inflammation of the kidney in its attempt to excrete organisms or their toxins swept into the blood stream at operation.

Chronic parenchymatous nephritis constitutes a risk so grave that wherever possible alternative means of treatment to operation should be adopted. Renal œdema and susceptibility to infection go hand in hand, and acute pericarditis, pleurisy or pneumonia is a not unlikely sequel, if the other danger of anarsarca and suppression of urine is escaped.

Chronic interstitial nephritis is a less serious risk, the dangers in marked cases being from uræmia or from vascular accident such as cerebral hæmorrhage.

Where operation must be performed in spite of the handicap of nephritis, the renal function must be improved as far as possible by adequate rest, removal of toxic contributory causes, restriction of protein intake, giving of alkalis and liberal fluids (apart from œdema), and free excretion by the bowel.

Operation on one kidney, e.g. for calculi, demands, first of all, separate investigation of the function of both kidneys, as by collection of ureteric specimens of urine, cystoscopic inspection of the passage of special dyes from each ureteric orifice, or X-ray examination after injection of radiologically opaque substances (e.g. uroselectan-B) excreted by the kidney. One sound kidney is adequate to withstand any ordinary surgical risk; a previous nephrectomy for accidental injury, for example, need not be considered a bar, such is the normal renal reserve.

Cases of enlarged prostate with retention of varying degree, upon whom operation is contemplated, need perhaps the greatest care in determining as far as possible the renal reserve. How meagre at best are the available methods is well recognised, and linked up with the vast normal reserve of the organ. The urea-concentration test is on this account of little value. Estimation of the blood urea is of somewhat greater reliability, though still capable, by an apparently normal result, of giving a misleading prognosis in some cases. A figure above 40 mg. per 100 cc. indicates some renal damage, while above 60 mg. the surgical risk of a one-stage operation is high, and preliminary bladder drainage indicated. The most satisfactory test available is estimation of the Blood Urea Clearance (Van Slyke), any reading below 60 per cent

of normal signifying damaged renal function and carrying with it a poor surgical risk (see Vol. I, page 135).

The value of the much-neglected ophthalmoscopic examination of renal cases may be mentioned. The presence of albuminuric retinitis *may indicate more clearly than any chemical test an impending uræmia.* As already pointed out, the cardio-vascular system cannot be divorced from the renal and must be simultaneously investigated.

A few points are worthy of consideration relating to medical aspects of primarily surgical conditions of the renal system. In connection with genito-urinary tuberculosis, the frequency should be borne in mind with which these lesions are secondary to pulmonary tuberculosis, and an X-ray examination of the chest never omitted, even in the absence of physical signs. Both as regards anæsthetic precautions and possible tuberculin treatment, this investigation is of value. In the former case lighting up of disease may follow ether inhalation; in the latter *a great risk is present of an acute allergic flare of activity in* the lungs, and tuberculin injections should be sedulously avoided.

In any condition of apparent unilateral hydronephrosis the possibility is to be remembered of its being in fact a congenital cystic disease of the kidney confined in the early stages, as is not very uncommon, to one organ only. The symptoms in polycystic disease are those of chronic interstitial nephritis, as are the urinary and cardio-vascular changes. Removal of the one kidney will but shorten the resistance of the other, should this subsequently become affected.

Chronic cystitis or pyelitis, under-explained from the surgical aspect, should always cause attention to be directed to the nervous system, *to exclude its being a trophic lesion associated with spinal* cord disease, such as tabes dorsalis, myelitis or disseminated sclerosis. A similar cause may account for obscure bladder pain, strangury, and delayed or precipitant micturition.

A point of difficulty sometimes met with in differential diagnosis is worthy of note. Renal embolism in medical conditions is apt to be confused with renal colic, each being associated with shock, sudden pain in the loin, and hæmaturia. Investigation of the heart will indicate the source of infarction. The not uncommon occurrence of renal pain and hæmaturia from passage of oxalates is another source of confusion, and an inquiry as to the taking of strawberries, rhubarb, spinach or tomatoes may give the clue in diagnosis.

D. Surgery of the Biliary System

If renal function is difficult to determine, hepatic function is doubly so. The known tests have on occasion failed to demonstrate damage when post-mortem examination has revealed, for example, replacement of two-thirds of the organ by growth.

The clinical condition is the best guide where the safety or otherwise of operation is at issue. Chemical tests of the urine for bile-salts and pigments and for urobilin may, if required, be supplemented by examination of the blood for its *Van den Bergh Reaction and Icterus* Index. The ability of the liver to store lævulose and galactose may be determined, together with its capacity to eliminate special dyes by the biliary passages, cholecystography being a special application of this method. Finally, where desired, the secretion of the liver may be directly examined by duodenal intubation.

The main risks to the surgeon arise in conditions of obstructive jaundice, when the hepatic metabolism is upset by damming-up of the liver cells with bile. Other conditions where operation is dangerous include cirrhosis of the liver, with portal obstruction and its accompanying venous stagnation and ascites, and states of toxic hepatitis, whether from drugs, chemical poisons or infection.

The risks of jaundice are chiefly two-fold, namely, hæmorrhage and post-operative acidosis or cholæmia, described in a previous section (see Vol. I, page 748). Estimation of coagulation-time of the blood gives some index of the former risk.

Chronic obstructive jaundice is of itself an indication for surgery when it may by such means be relieved, so great is the danger of liver failure if obstruction be allowed to remain. Preliminary treatment will be dietetic, by restriction of fats and giving of abundant bland fluids and glucose, with cholagogues and saline aperients, simple diuretics and alkalis. Glucose may, if desired, be given by the bowel, or intravenously in 5 to 10 per cent solution in saline, while its rapid utilisation is aided by giving 10 to 20 units of insulin at the same time. The danger of hæmorrhage at operation is lessened by administration of citrates in full doses for a few days previously, with injections of calcium gluconate, while a pre-operative blood-transfusion is also of value. Shock is common with liver damage, owing to the reduced ability of the organ to detoxify the histamine-like substances produced by trauma, and intravenous injection of 6 per cent gum saline may help to counteract its effects. The choice of anæsthetic must be that least toxic to the liver cells and least disturbing to their carbohydrate metabolism,

preferably ether or gas and oxygen in conjunction with a local anæsthetic.

The gall-bladder is an organ of both medical and surgical interest. From the medical standpoint it is probably one of the most frequently overlooked foci of general intoxication. Its affections are, moreover, not always easy to diagnose from thoracic disease. The ease with which the pain of chronic cholecystitis may be mistaken for angina deserves special recognition, while the reverse is also true in that an apparent biliary colic may, in fact, originate from coronary infarction. The liability of a tender, congested liver being interpreted in error as chronic cholecystitis may also be mentioned.

There is, moreover, a special tendency for chronic infections of the gall-bladder to bring about a toxic degeneration of the heart muscle. Care of the heart in gall-bladder operations is thus particularly indicated.

With regard to cirrhosis of the liver, the need for its exclusion is evident before any operation is carried out for hæmorrhoids or hæmatemesis. Treatment, moreover, of ascites from this cause by short-circuit operations is seldom a justifiable undertaking. The risks of infection, portal thrombosis and cholæmia are grave.

E. Metabolic Disturbances: Diabetes Mellitus

The surgical risks peculiar to the diabetic subject are of two kinds. In the first place, there is in this disease a special liability to a group of complications of surgical significance, dependent upon a combination of vascular or trophic disturbance with metabolic upset. These include gangrene, skin sepsis, trophic ulcers, and cataract, each of which needs appropriate modifications of treatment.

The second group concerns the added risk of diabetes as it affects general abdominal or major surgery. This has already been reviewed *in a previous section (see Vol. I, page 790), and a brief summary will* therefore suffice. Whereas prior to the discovery of insulin the dangers of surgery were maximal, it may now fairly be said that, given reasonable facilities and time for pre-operative treatment, the additional risk is slight.

The principle in operations of choice is that the patient should, by generous feeding and liberal use of insulin, be got into the best physical condition to withstand operation, with carbohydrate metabolism so balanced that no glycosuria or acidosis is present and the blood sugar is at a normal level. Any preliminary septic factor is treated where possible.

Immediately before operation is carried out, an adequate reserve of sugar in the liver is ensured by giving glucose and insulin in appropriate amounts, continuing the same care in the post-operative phase, controlled throughout by blood-sugar and urine tests. Operative trauma is reduced to a minimum and a suitable choice of anæsthetic made, commonly gas and oxygen, with basal, spinal or local anæsthesia also if desired. Special watch is made for hypoglycæmia in the recovery stage.

Acute abdominal (or other) surgical emergency in the diabetic produces more profound disturbance of metabolism—perhaps coma, and the dangers and difficulties of treatment are correspondingly increased. Diagnosis itself may be obscured. Necessary surgery is not to be shirked or postponed, even in the presence of coma. The principles of conduct of the case are essentially as outlined above, except that far larger doses of insulin and glucose are required. It is also no less important to give abundant fluids, in order to counteract previous dehydration.

F. Endocrine Disorders

(1) *Surgical aspects of hyperthyroidism.* Whether or not in toxic goitre the primary disturbance is within the thyroid gland, the most successful means of treatment available still remains a partial thyroidectomy. The proportion of established cases permanently restored to health by medical treatment alone is small, and the recent trend of opinion is to refer an increasing number of cases to the surgeon, and at an earlier stage of illness. The risks of permanent cardiac incapacity from thyrotoxicosis and the dangers of operating on the desperately advanced case are both thereby avoided. Milder cases may not, however, require the aid of surgery, and decision where and when to operate is an eminently suitable circumstance for consultation between physician and surgeon.

The previously high mortality of thyroidectomy has been greatly reduced by careful choice of case, preliminary medical treatment, suitable premedication and anæsthesia, and skilful operative technique, the death-rate being now as low as 1 per cent in competent hands. Every thyrotoxic patient should first pass through the physician's hands. Before operation is decided upon, complete rest in bed should be enforced for at least a month, and contributory sepsis as in teeth or tonsils eradicated. The maximum of mental and physical rest is obtained with the help of sedatives such as bromide and luminal, and an attempt is made to improve the patient's nutrition by

dietary measures. If, as is not infrequently the case, auricular fibrillation is present, digitalis is given in sufficient amount to control the irregularity, larger doses often being needed than those customarily adequate in non-toxic fibrillation. An estimation of the basal metabolic rate at progressive stages of treatment affords one of the most valuable guides to improvement.

Where the results of preliminary rest and medical treatment point to the need for surgical intervention, the B.M.R., for example, remaining above 50 per cent of normal, the patient is given iodine by mouth to produce a *phase of remission optimum for surgery*. The giving of Lugol's iodine (5 per cent iodine with 7·5 per cent pot. iodide in distilled water) in doses of 5 minims t.d.s. in milk, for a period of two to three weeks, ensures the maximum of remission. This is the correct use of iodine in toxic goitre, and not indiscriminate dosing for months or years *on end. On the day prior to operation, and on the subsequent two days*, double this dosage is given by mouth.

Apprehension on the part of the patient is minimised by basal premedication, while the most satisfactory anæsthetic is gas and oxygen combined with local infiltration of novocaine. Immediately after operation one drachm of Lugol's solution is given per rectum in a glucose-saline enema and repeated at intervals as may seem necessary.

Occasionally, operation is followed by an acute thyrotoxic crisis, shown by restlessness, delirium, rising temperature, extreme tachycardia, and sometimes vomiting and diarrhœa. In these circumstances, drachm doses of Lugol's solution may be repeated six-hourly by the rectum, or in emergency 20 minims of the solution given intravenously at the same interval, diluted in 10 cc. of saline or given with a 5 per cent glucose-saline infusion. Rapidly acting cardiac stimulants such as coramine, with digitalin, may be required, and full doses of sedatives; if bromide and chloral hydrate are inadequate, morphia should be given without hesitation.

After the operative phase, iodine by mouth should be continued for two to three months in the form of Lugol's solution, 5 minims twice daily. A spontaneous return of the fibrillating heart to normal rhythm is frequent; if necessary, quinidine may be given. Abnormal rhythm is never a contra-indication to surgical treatment, nor even heart failure if due primarily to the goitre.

Consideration of the thyroid gland in its relation to medicine and surgery would be incomplete without reference to the value, in some cases of gross congestive heart failure unresponsive to medical treatment, of total removal of the thyroid gland. The lowering of basal

metabolism so obtained gives the circulation in such cases a further chance of improvement.

(2) *Other endocrine disturbances.* With other endocrine glands questions of medicine and surgery overlap to a much less extent. Suprarenal tumours may masquerade as medical cases and come under observation for obesity or hirsutism, while removable tumours of the pituitary are generally first seen by the physician. In both instances, *although the risk is high, operation is the correct advice.*

Tetany sometimes occurs after operation for removal of a parathyroid tumour, and treatment consists in administration of parathyroid extract and of calcium salts by intravenous injection.

Unexplained surgical death is sometimes attributed to status lymphaticus and the blame placed upon a supposed thymic disturbance; the significance or otherwise of such deductions is reviewed on page 4257.

G. Medical Considerations in Gastric Surgery

No attempt is made here to review this vast and interesting subject. In no section of therapeutics is a greater co-operation to be desired between physician and surgeon. One would make the general plea, in these days of rapid change, for peptic ulcer still to be regarded as a medical disease, in which surgical co-operation is to be desired in well-defined circumstances. While not doubting the successful progress of gastric surgery, every case should nevertheless be given the opportunity of an adequate trial of medical treatment in the first instance. Failure of such medical treatment to make the patient's life bearable, doubt as to malignancy, or the occurrence of special complications *may then all severally justify surgical intervention.* (See also Vol. I, page 297.)

The value and place of histidine in the treatment of peptic ulcer awaits further trial, but the results so far have proved disappointing.

A second plea is for torrential hæmatemesis to be treated invariably by medical rather than by surgical means. Operation at such a stage of illness is fraught with danger.

In evaluating the operative risk in any given case of chronic peptic ulcer, the factors to be borne in mind are the duration, position, size, and fixity of the ulcer, and any doubt present as to its possible malignancy. The general condition of the patient is a further deciding factor, and should always be improved as much as possible before operation is undertaken. Special knowledge of gastric surgery, skill in technique and care in anæsthesia frequently determine the issue.

in hæmorrhagic purpura is usually followed by recrudescence, perhaps with fatal hæmorrhage—a further reason against delay.

(4) *Other conditions with splenomegaly. Gaucher's disease* in infants has sometimes been treated by splenectomy, but the late results are disappointing, as shown by Pick and Maingot. In other conditions associated with enlargement of the spleen and blood changes, including leukæmia, pernicious anæmia, and lymphadenoma, no lasting benefit has been shown to accrue from removal of the spleen. In doubtful cases of glandular enlargement, surgical biopsy of a gland may, however, be of great value.

In conclusion, and reviewing the question of surgical risk as a whole, the lesson of history must not be forgotten. Fifty years ago it was generally fatal to open the abdomen. A craniotomy for cerebral tumour provided a short-cut to the post-mortem room. Now recovery has followed the removal of the entire stomach, the whole of one lung, or an entire lobe of the brain. Although, alas, we are told by some that *surgical technique has reached its zenith of achievement, it is,* however, scarcely conceivable that either surgical or anæsthetic skill has attained a stage no longer consistent with further progress.

PART XVIII

HERNIA

by

W. HENEAGE OGILVIE

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HERNIA

CHAPTER I

Introduction

A hernia is the displacement of an organ from the cavity in which it is normally contained through an opening in the walls of that cavity. For the present purpose herniation of the abdominal contents only will be considered, and discussion will be limited to the more common and important varieties. The opening through which a hernia occurs is usually either a natural foramen or channel through which blood-vessels or other structures leave the abdomen, or the site of some injury. Thus the common sites are the inguinal and crural canals, the umbilicus, and the scars of operations. Under conditions, however, in which prolonged or repeated increase of abdominal pressure coincides with general wasting, almost any of the fibrous junctions in the abdominal wall may give way. Such anomalous herniæ may be found in the very old and debilitated inmates of public institutions, who throw the strain of constant coughing on abdominal walls shrunken to paper thinness; in such it is not uncommon to find four distinct herniæ in each groin, protrusions through the linea semilunaris and under Poupart's ligament lateral to the femoral artery, in addition to the more common inguinal and femoral ones.

A patient will sometimes present himself with a large hernia which has clearly been in existence for a considerable time, but which has only been noticed accidentally by him within the last few days. Another will say that he has known of the swelling for several years but it has given him no trouble whatever, and he has only sought advice because his employers insisted on it or his friends advised it. Usually, however, some disability is occasioned from the start. But in any case, whether the hernia is causing trouble or not, when a surgeon discovers it, he is bound to advise control or cure, that is, some retentive or protective apparatus or an operation. For no hernia left to itself will undergo cure, remain stationary, or even be tolerable for any length of time. The hernia itself is the result of abdominal pressure acting on a weak spot, and abdominal pressure is a constant force, maintaining the position of the viscera, keeping up the flow of blood in the great veins, and aiding the return of the diaphragm after its descent. It is increased

to expel the contents of the abdominal or thoracic viscera, or to fix the trunk as a base for the limbs—that is, in vomiting, micturition, defæcation, parturition, coughing, or muscular work. With this force constantly acting, any hernia is bound to increase in size, while the hernia in turn will tend to inhibit and interfere with abdominal movements and give a feeling of insecurity during any strenuous exertion. To these disabilities is added the danger of strangulation, present at all times in some herniæ, but only appearing later in others. No hernia, therefore, may safely be disregarded, and some form of treatment should be insisted upon as soon as the diagnosis is certain.

Because it is inherent in human nature to avoid any course of action which involves risk, pain, or loss of time, a great many patients will wish first to discuss the question of a truss. The brilliant results of operative repair in herniæ of moderate size are sufficiently well known to-day to induce the majority of young and active men to demand surgery, but on the other side are the skilfully worded advertisements of those who claim to "build up the tissues" by simple apparatus, so that very often the surgeon is called upon to state simply the pros and cons of treatment by apparatus. In very general terms it may be said that apparatus is not curative but merely retentive, and must therefore be worn permanently, not merely all the patient's life, but at all times of the day and night. It is therefore irksome to an extent that varies with the sensibility of the patient, the type and strength of the apparatus that he requires, the nature of his work, and the delicacy of his skin. It is only effective if it is made exactly, worn constantly, kept in repair, and renewed when weak. It is more effective in some type of herniæ than others, but in all it is liable to produce some degree of pressure atrophy in the tissues upon which it rests, and therefore to become less effective with time. On those general grounds alone, the adoption of apparatus should be strongly discouraged in the young and healthy.

Two particular questions are often asked: "Can a truss cure a hernia?" and "Can a truss retain a hernia, prevent it enlarging, and allow work in reasonable comfort and without the risk of strangulation?"

Cure is possible in the inguinal or umbilical herniæ of infants, but in these alone. A congenital inguinal hernia is due to persistence, in whole or in part, of the processus funicularis or the canal of Nuck, diverticula from the cœlomic cavity which normally remain patent till just before birth. Their persistence after this somewhat arbitrary date is evidence of delay, but not necessarily of failure in the process of

obliteration, which may still take place naturally some weeks or even months later if allowed to do so. For such a natural cure it is necessary that the sac should be, and remain, empty. A truss must, therefore, be worn continually day and night for the first year. If the hernia comes down during this trial period, any possibility of closure is probably lost, and if it appears after the end of a year when the truss has been left off, it is highly improbable that natural closure can then take place.

An infantile umbilical hernia is an acquired defect, due to stretching of the newly formed cicatrix. If protrusion of abdominal contents is prevented by a suitable binder and pad, the scar tissue will contract once more and become strong, and a natural cure will result. Such a cure may confidently be expected by the end of six months in the great majority, but may take place up to eighteen months. After this time it is, however, unlikely.

It is theoretically possible that the prolonged wearing of a truss might bring about the natural cure of an *oblique inguinal hernia*, even in adult life, by the formation of adhesions between the walls of the sac at its neck obliterating the internal ring. It is, however, excessively unlikely that such adhesions would occur exactly at the ring or that they would completely obliterate the lumen. They are usually between the sac wall and its contents, and not at the commencement of the sac, but half an inch or so further down, where its walls are pressed together by the pad; further, they are usually bands or partial adhesions. Such attempts at repair have no value in preventing the entry of the abdominal contents into the sac, but rather favour strangulation when they do come down.

The *second question*, whether a truss can retain a hernia with comfort and safety, can only be answered with regard to particular herniæ.

OBLIQUE INGUINAL HERNIA

If the hernia is an early one, that is, whatever its size, if the neck is small, the internal ring neither stretched nor displaced inwards, and the muscles good; in other words, if the hernia, when reduced with the patient standing, will not come down again unless he coughs, strains, or walks about, it can be retained with certainty by a well-fitting truss against any but the most violent straining efforts. On the other hand, this type of hernia is usually seen in young healthy men, and is one for whose cure only a simple type of operation is necessary, and in which a permanent cure is almost certain. In proportion as the hernia is old, the internal ring enlarged, the muscles weak, or the patient's occupation strenuous a truss will be less effective. *The continual wearing of*

a truss over an oblique inguinal hernia tends in time to produce atrophy of the inguinal muscles, thickening of the sac near the internal ring, and adhesions between the sac and its coverings and contents. Such changes have two results. Abdominal contents coming down into a hernia pressed on by a truss are much more likely to become strangulated than where no truss has been worn; and an operation when it is required cannot rely upon simple removal of the sac, but must include some plastic manœuvre to strengthen the inguinal canal.

DIRECT INGUINAL HERNIA

A direct hernia, unless it is really large, is particularly suitable for a truss. It appears late in life, it tends to enlarge very slowly, and it can be retained by the simple backward pressure of a pad, and when so retained will not increase appreciably over many years. The sac is wide-mouthed, and there is no tendency for adhesions to form in or around it, or for contents to be trapped in it. It will be found that many seamen and general labourers are able to carry out their strenuous callings wearing double inguinal trusses for direct hernia without any appreciable loss of efficiency. Here, then, a truss is effective and safe. Operative repair, on the other hand, implies some fairly elaborate method of reconstruction, whose permanent success cannot be assured with complete certainty.

FEMORAL HERNIA

While in inguinal hernia a truss is usually effective, and is merely discountenanced in many cases because it is unwise, in femoral hernia it should only be recommended for most exceptional reasons. The hawker of patent apparatus will shout his ability to cure all femoral herniæ; the instrument maker is always ready to make a femoral truss. But a survey of the anatomical factors concerned will throw considerable doubt upon the efficiency of any mechanism to control such a hernia. The inguinal canal belongs to the trunk, and a well-made truss embracing the pelvis will lie securely during all movements, and maintain an even pressure on the weak spot. The femoral canal is in the thigh, and all movements at the hip must necessarily displace a pad lying over the saphenous opening and attached to a spring or girdle encircling the trunk. Even were it possible to maintain even and continuous pressure on the crural canal (as it would be, for instance, in a patient with an ankylosed hip-joint) such pressure would only be effective on the fundus of the sac and the distal half of the canal. The neck of the sac and the abdominal end of the canal lie behind and

above Poupart's ligament, where any pressure, short of that which will rupture Poupart's ligament and obstruct the femoral vein, is powerless *to prevent the entry of abdominal contents into the hernia.* The potential dangers of a femoral hernia are far greater than those of any other type. Strangulation is commoner, progresses more rapidly to gangrene, and is more fatal in its outcome. A truss should never be ordered, or countenanced if the patient suggests it, except in those rare wide-mouthed and easily reducible swellings, where the age or health of the patient prohibits an operation even under local anæsthesia.

UMBILICAL HERNIA

In the umbilical herniæ of infants, a belt with a pad, or even a home-made retentive apparatus of strapping, will usually retain the protrusion, and will effect a cure by the end of the first year in the majority of cases. Here the abdominal wall is normal and unstretched right up to the edge of the orifice, there is little subcutaneous fat, and the pad will remain in position over the opening and keep the sac empty. In adults the state of things is usually different. The whole abdominal wall is sagging, the linea alba stretched, the hernial orifice a somewhat indefinite opening lying beneath a thick layer of subcutaneous fat, the sac loculated, and the contents usually reducible in part only, if at all. It is difficult to maintain a pad in the correct position or to apply its pressure to the ring, and even if the hernia can be reduced and kept back, it will slip past the pad with any extra exertion or sudden movement of the abdominal wall. Because of the liability of these herniæ to strangulate, and the high mortality of the complication, a truss should only be advised for small and completely reducible swellings where the risk of operative repair is considered prohibitive.

INCISIONAL HERNIA

The efficacy of a belt depends entirely upon the size and character of the hernia. A wide bulge involving the whole scar can usually be retained well by a belt alone, or by a belt with a pad over the protrusion; it will not increase in size, and the belt will allow a fairly normal life and a considerable degree of exertion. When, on the other hand, the sac has a large fundus, with a narrow neck passing through a small aperture in rigid scar tissue, control by any form of pad is uncertain, and strangulation, on account of the deficiency in the peritoneal lining and the many adhesions, is extremely likely.

THE PLACE OF APPARATUS IN THE TREATMENT OF HERNIA

The foregoing remarks may be summed up as follows:

(1) *A truss should be ordered:*

(*a*) *As a possible method of cure* in all inguinal and umbilical herniæ of infants during the first year of life. Operation should only be undertaken during this period for progressive increase in size in spite of conscientious use of the truss by the mother; for inability to wear the truss owing to skin soreness or other reasons; or for threatened complications.

(*b*) *To prevent increase in size and avert the risk of strangulation* in a case where operation will be undertaken at a later date. In inguinal and umbilical herniæ of infants from the end of the first year (after which a cure can no longer be expected) till the earliest suitable age for operation (in my opinion four years for inguinal, two years for umbilical hernia). In oblique hernia in adults, when operation is advised, but postponed for social or economic reasons, or on account of general or local disease.

(*c*) *As a safeguard after an emergency or limited operation,* which cannot be regarded as a radical cure. In many operations undertaken for strangulation, or in the aged for threatened strangulation, the sac is removed, but the measures that would appear necessary to render the canal proof against yielding in the future have not been carried out because of the condition of the patient. In such cases a truss with quite light pressure is usually sufficient to prevent a recurrence.

(*d*) *As the only possible safeguard* in all *reducible* herniæ when operation is out of the question.

(2) *A truss may be permitted* in most direct inguinal and many incisional herniæ, and in oblique inguinal hernia where the patient is a poor operative risk.

(3) *A truss should be discouraged* in oblique inguinal hernia if the patient is healthy.

(4) *A truss is dangerous* in femoral herniæ, in the umbilical herniæ of adults, and in incisional herniæ with a small rigid opening and a large sac.

GENERAL PRINCIPLES IN THE OPERATIVE REPAIR OF HERNIA

The basic principles of hernia surgery are simple—the removal of the sac at its neck, and the closure of the hernial canal at its commencement. Of these two demands the second is the more important. There may be no sac, the sac may have no neck, or it may be so short and wide that its removal is unnecessary; but, except in certain instances, secure closure of the hernial orifice is an indispensable step without which the removal of the sac is of no more than temporary value.

The chief exception is an oblique inguinal hernia with a congenital sac into which contents have only recently and occasionally descended. In such there is no "hernial canal" or "hernial orifice" in the sense of an abnormal opening. The internal inguinal ring is a normal aperture and only becomes abnormal when it is stretched. In a hernia of the type under discussion the only abnormality is in the structures passing through the ring; there should be vas, vessels and nerves only, but in such a case there is, in addition, a collapsed peritoneal pouch. If the pouch is entirely removed, all abnormality is removed with it, and the inguinal region becomes normal.

In all other cases, however, the opening is an abnormal one, which must be securely closed after removal of the sac. The method required for closure will depend upon the size of the opening and the nature and power of repair in the tissues which bound it. In some cases the tissues in the neighbourhood, drawn together by absorbable sutures, will provide satisfactory repair; in others, some such closure must be reinforced by drawing down adjacent tissues or turning in flaps from structures in the neighbourhood: in others, free transplants of living connective tissue from some other part of the body may be used to repair the defect; in others again, unabsorbable foreign material may be used. The principles alone of these different methods can be discussed here; their detailed application must be left to the consideration of individual herniæ.

In most surgical operations catgut is used to-day for all deep sutures. Its value is that when its work is done it is entirely absorbed, leaving nothing but living tissues at the site of operation. It must be remembered, however, that the work of catgut, indeed of all sutures, is one of approximation only. No sutures, even unabsorbable ones, can keep tissues together against tension tending to separate them, for more than a short time. In the face of continued tension, sutures, if not absorbed, will cut out, and the parts will return to their original site unless they are fixed by the permanent agency of living connective

tissue. Thus there is little value in the stouter sizes of catgut; indeed, in this material size is little indication of strength. In my experience No. 0 and even No. 00 is usually as strong as No. 1, and the sizes above No. 1 are often weaker and more unreliable than the finer ones. Moreover, catgut, though it can be absorbed, is a material not received kindly by tissues. It produces considerable reaction, as any surgeon who has been obliged to reopen a wound for any purpose during the first ten days after suture will have been able to ascertain for himself. In the presence of infection, it resists absorption, and prolongs local sepsis till it is discharged.

Kangaroo tendon provides an absorbable suture material of greater strength than catgut. While this strength gives it a place in bone surgery, it is very doubtful, for the reasons given above, whether the parts concerned in hernia repair should ever be subjected to a tension which cannot be exerted by sutures of No. 1 catgut. In my opinion the bulk of kangaroo tendon, and the insecurity of knots made with it, prohibit its use for this class of work.

The use of free transplants of connective tissue is old in surgery, but the investigation of factors concerned in their successful application, and the development of a satisfactory technique, is the work of Gallie. He showed that connective tissues, when transplanted free to another part of the body under aseptic conditions, remain alive, and after undergoing a transient inflammatory reaction, regain their original microscopic appearance. Thereafter they remain unchanged, retaining their strength and structure indefinitely. They become united to their surroundings by fibrous tissue. If this is abundant, as when the edges of the transplant and its bed are scarified or when non-absorbable sutures are used, the union will be firm; if the connective tissue is small in amount and subjected to strain, the union between the graft and its bed will become stretched. By using strips of fascia woven into the receiving tissues instead of patches stitched to them, the graft becomes incorporated with its bed by a living union and displacement is impossible.

Gallie sutures are usually taken from the fascia lata on the outer side of the thigh. The original technique is to make an incision about 12 inches long down to the fascia lata, reflect the superficial fascia backwards and forwards for the requisite distance, and cut parallel strips ¼-inch wide from the fascia. When the gap following removal is not much over an inch wide, it may be closed with interrupted stitches of catgut. If, however, the edges can only be got to meet with considerable tension they should be left unclosed. Direct exposure of the fascia is

time-consuming, and occasions a certain loss of blood. By transferring this part of the operation to an assistant, who cuts the strips while the surgeon prepares the hernia, and closes the thigh while he inserts them, both disadvantages are minimised, but a large scar remains in any case. Instruments whereby the strips can be cut through small transverse

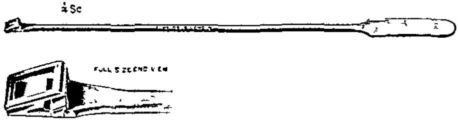
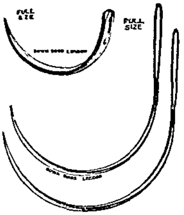


Fig. 1981.—Small's fasciatome.

incisions at either end of the ilio-tibial band are the most obvious solution. The difficulty to be overcome is that, unless the fascia is cleared of other tissues on both its surfaces, it will not separate easily into neat parallel strips. The early fasciatomes used to bring out ragged irregular wisps with fat and muscle adhering; modern ones, of which Small's (fig. 1981) is an excellent example, are entirely satisfactory. Clean regular fascial sutures of full length can thus be cut with a minimum of trauma, and open exposure will only be used when the

Fig 1982.—Needles for fascial suture.
(*Top*) Gallie's.
(*Bottom*) Lane's.



surgeon is not provided with the apparatus, or when he wishes to get the maximum number of strips from one limb, or one or more of extra width. There is, of course, no particular merit in the fibres of the ilio-tibial band, beyond their length and number. For limited operations, suitable aponeurotic strips may *often be cut from tissues in the* immediate neighbourhood of the operative field. In the repair of inguinal herniæ such strips may often be obtained from the external oblique aponeurosis. The fascial strips are used with special needles. Gallie's (fig. 1982) are flat needles with a half-circle curve and a wide eye to take the suture; Lane's are of lesser diameter, the eye being replaced

by a wire loop. One end of the suture is passed through the eye and tied over itself with fine silk; the free end is similarly tied with silk to prevent splitting. "In taking the first stitch the needle is passed through a tough portion of the edge of the gap to be closed and then through the terminal end of the suture (fig. 1983). In this way a slip-knot is produced which forms an excellent anchor. The suture is woven strongly into the edges with as many bites as seem necessary, and passed backwards and forwards across the opening until its whole length is used up. Owing to the slippery character of the fascia it will be found useful to anchor the sutures at every second or third stitch by some form of

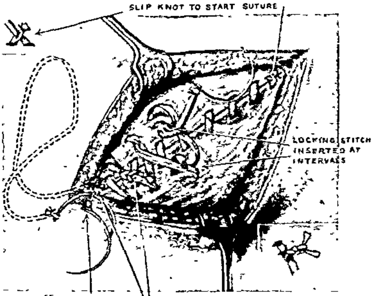


FIG. 1983.—TO ILLUSTRATE THE METHODS OF FASCIAL SUTURE.

knot (fig. 1983). We usually combine a single loop-knot with transfixion. When the first suture has been used up a second may be attached to it in the same way as pieces of tennis gut are fastened together, and the sewing continued. In this way one suture after another may be inserted until the opening is completely closed. The suture is finally ended by splitting its terminal portion into two strands which are tied together about the suture in a triple knot. This knot should be made secure by transfixing it with a catgut ligature which will hold its loops in contact until they become firmly healed together."

While fascial suture will solve most of the problems that can possibly confront the surgeon in the way of repair, it must be remembered that fascia lata, or any aponeurosis transmitting the pull of a muscle, is

strong only in the direction of that pull. Its longitudinal fibres are held together by very few transverse ones, and large patches, even when securely anchored all round, are quite unfitted to take a strain applied equally to all their margins. The body, however, possesses in the derma a connective tissue sheet of almost unlimited size and strength, a felt-work of tough interlacing fibres equally strong in all directions. We use derma to sole our boots, cover our saddles, drive our machinery; paraphrased, one of the oldest sayings runs "there's nothing like derma." Rehn of Freiburg has shown the many uses to which dermal transplants may be put, among others for reconstructing the capsules

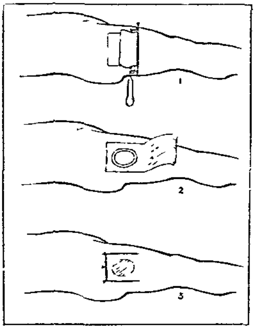


Fig. 1984.—Preparation of Rehn's dermal transplant.

1 A hinged Thiersch graft is cut with a Humby razor.
2 A graft of the required size is cut from the derma
3. The Thiersch flap is stitched back over the defect

of joints and repairing really large defects in the abdominal wall which may follow severe sepsis in operation scars, or the excision of large areas for malignant disease.

A dermal transplant should be cut the size of the defect to be covered. After the defect has been defined, a template may be cut in sterile jaconet. With a skin-graft razor, of which Humby's pattern is the most reliable when large areas are concerned, a Thiersch graft, somewhat longer than the dermal patch required, is cut from the outer side of the thigh, but left hinged at one end (fig. 1984). The jaconet template is applied to the denuded derma, and the required patch cut round and dissected off with some underlying fat. The Thiersch flap is laid back on the raw surface which remains, retained in position with three or four marginal stitches, and pressed down with a firm dressing. The dermal patch is transferred to the defect, the fatty layer towards

the surface, the superficial layer downwards, being stitched in position with interrupted sutures of silk, or fascial strips. Being to some extent elastic it will overlap the margins of the defect all round, and afford a wide area by which it will adhere to the underlying tissues.

Many unabsorbable materials have been used from time to time in the repair of hernia, but the majority are of no more than historic value. Two only merit discussion at the present time—silver-wire used in the form of a filigree, and silk. The silver-wire filigree can be obtained in any size or strength, and may easily be made by the surgeon himself, from materials that are everywhere available, to suit the needs of a particular operation. It is easily sterilised, is usually well tolerated by the tissues, and becomes in time incorporated in a dense web of fibrous tissue of which it forms a strong framework. The disadvantage of such a filigree is that it is rigid and therefore cannot move with parts which, in all herniæ, are subjected to movement. It is true that in the great majority of cases such rigidity causes no recognisable trouble. But, like all unabsorbable materials, silver-wire will, in the presence of infection, whether present when it is inserted or arriving later by the blood stream at the site of operation, keep up the infection indefinitely. The damage which a rigid material may cause among moving tissues makes such infection commoner with wire than with silk. Sepsis will persist till the foreign body is removed or eliminated; but whereas silk under such circumstances can be discharged piecemeal through a very small sinus, a silver-wire filigree can only come out as a whole. Till this happens it will lie in an abscess-cavity, and may cause serious or even fatal damage by eroding a large vessel or a loop of intestine. *In my opinion the perfection of modern* methods which depend upon the use of fascial or silk sutures or large dermal transplants has left no place for the filigree. It must be admitted, however, that some surgeons are very satisfied with the method to-day. Any who consider that the use of a filigree may solve some problem in the repair of hernia with which they are faced would do well to consult the article by Laurie McGavin in the first edition of Choyce's *System of Surgery*, Vol. II, Chapter II.

Silk is used much more widely as a suture material on the continent of Europe than in England and America. Yet it has very much to recommend it. It is more pliable and more than twice as strong as catgut of the same diameter. It knots securely; silk ligatures may be cut " on the knot," whereas catgut must be cut two or three millimetres beyond the knot, which even then will often come undone if subjected to intermittent strain. *Because of its security, fine silk is employed by*

many surgeons for the ligature of vascular structures subjected to constant movement—notably in thyroid work. Silk, again, is received by the tissues much more kindly than catgut, producing no appreciable reaction. For this reason it is used almost universally in the exacting technique of neuro-surgery. In common with all unabsorbable foreign materials, it will keep up any infection which is present when it is introduced. Silk should never be applied to any operation where infection is feared, as in those on herniæ where the skin is sore from the pressure of a truss, or excoriated in the folds of a pendulous groin. When it is used, special care should be exercised in the arrest of hæmorrhage and the obliteration of dead spaces in the wound during closure, to prevent any blood-borne infection of the tissues later. With these precautions silk will be found an excellent servant in hernia surgery. Should infection supervene, silk does not aggravate it, but merely prevents the healing of the wound. Once an opening has appeared, it settles down to a small sinus with none of the signs of inflammation, and through this the silk is quietly and painlessly extruded, having usually in the meantime done the work for which it was inserted.

Fascial sutures and silk compete for the surgeon's patronage when he desires to bridge a weak area with a firm sheet of connective tissue which cannot yield. Fascial suture may appear to the scientific surgeon to have a sounder claim. The material is an autogenous transplant, which retains its strength and microscopic structure unimpaired, and which is woven into the tissues and becomes incorporated by living bands into their substance, which when so incorporated becomes part of them and therefore shares their resistance to later infection. The practical operator, who is forced to admit that even the teaching of experimental animal surgery must be correlated with clinical experience, will also remember disadvantages. Fascial suture always adds an operation on the leg to one on the hernia ; it adds its time and severity, and almost prohibits the use of local anæsthesia. In post-operative infection fascial strips will slough like any other suture material. Perhaps the most obvious disadvantage is the size of the sutures themselves, which must be $\frac{1}{4}$-inch in diameter. These strips, and the coarse needles required to carry them, make a sorry mess of the delicate structures of the inguinal canal, particularly Poupart's ligament, which is very easily separated thereby into disconnected longitudinal strips. While admittedly no harm appears to result in most cases, the job is not one to please the surgeon whose ideal is atraumatic surgery. In my own opinion fascial suture is excellent for the repair of tendons, ligaments, and the capsules of joints, and of those abdominal defects whose margins are scar tissue

or felted aponeuroses—namely, umbilical or incisional herniæ. Where any such plastic reconstruction is required in the inguinal and femoral canals, I very much prefer silk, used in the same manner as fascial strips—that is, as a protecting lattice work and not as an approximating suture.

I always use Pearsall's No. 4 Chinese twist silk. This is boiled for ten minutes with the instruments, and the length to be used is put in $\frac{1}{1000}$ flavine solution till it is required. Some surgeons prefer silk in paraffin ; because I wish the fibroblasts to work freely between the fibres of the silk, and because paraffin is known to give rise to granulomata and occasionally to sarcomata, I never use this preparation.

CHAPTER II

Inguinal Hernia

THE INGUINAL CANAL

The post-graduate student is already familiar with the anatomy of the inguinal region, and it is only proposed to discuss here those points which have a bearing on the principles or technical details of the operations which will be discussed later.

The inguinal canal lies above the inner half of Poupart's ligament. The skin is smooth over the outer part, hairy towards the pubis, and at the level of the pubic spine has the rugose surface and large sebaceous glands of the scrotum and labium majus. The superficial fascia shows the layers of Camper and Scarpa; the latter, which is attached to the fascia lata of the thigh, must be divided with the knife before the femoral opening can be explored through an inguinal incision. A well-marked and constant flexure crease caused by the flexion of the trunk and thighs, and called by the old anatomists the line of Venus, is seen in this region. It crosses the mid-line at the hypogastrium about $1\frac{1}{2}$ inches above the pubis, and on each side it curves upwards as it passes out, crossing the line of Poupart's ligament in its outer fourth, and fading away on the outer side of the thigh just below the anterior superior spine (fig. 1985). I personally prefer to use this crease for the incision in all operations for inguinal and femoral hernia.

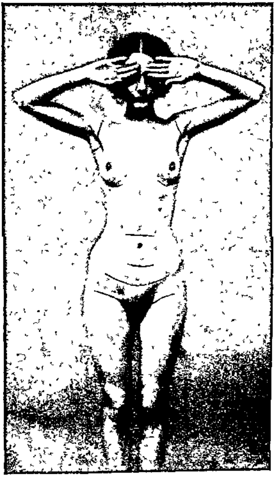


Fig 1985.—Flexion creases on the trunk of the normal adult.

It will rightly be urged that cosmetic surgery has no place in the pudendal region. But a good scar is more than a matter of appearance; it is a guarantee of comfort to the patient, and an aid to the surgeon who may have to operate again in the same region. The standard inguinal incision leaves a scar which is rarely sightly, sometimes keloid, and occasionally painful; these drawbacks are partly the result of its direction being in the line of tension of the skin, instead of in the line of rest as is a crease incision, and partly due to its encroachment at the lower end on skin that is sterilised with difficulty. In children the crease incision, by removing the stitches and dressings a further $\frac{3}{4}$-inch from the area of soiling, has very real advantages.

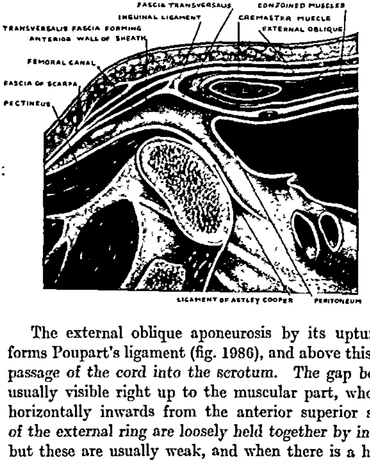


Fig. 1986.—Sagittal section passing through the inguinal and femoral canals, modified from a special dissection by Mr. J. Whillis. (The most important modification is that the cremasteric layer has been shown as muscle instead of fascia.)

The external oblique aponeurosis by its upturned lower border forms Poupart's ligament (fig. 1986), and above this splits to allow the passage of the cord into the scrotum. The gap between its fibres is usually visible right up to the muscular part, whose margin extends horizontally inwards from the anterior superior spine. The pillars of the external ring are loosely held together by intercolumnar fibres, but these are usually weak, and when there is a hernia in the canal, both they and the less obvious transverse fibres holding the aponeurosis together higher up are stretched. For this reason I have always disliked those methods of approach to the inguinal canal which make a point of leaving the external ring untouched. I believe that opening of the ring by dividing the intercolumnar fibres is necessary, not only for atraumatic reflection of the cremaster afterwards, but also to allow

the stretched ring to be sutured back to its normal size. Medially the external oblique aponeurosis joins the anterior rectus sheath, but it does so a full inch inside the outer border of the rectus muscle, so that for this width the sheath is formed by contributions from the internal oblique and transversalis only. The internal oblique springs from the outer half of Poupart's ligament, the transversalis from its outer third. Both muscles fuse to form the conjoined tendon, which arches over the cord to be inserted into the pubic crest and inner inch of the ilio-pectineal line. The cremaster arises from the inner half of Poupart's ligament and the lower border of the internal oblique, and descends over the cord as far as the testicle in the form of loops. Such is the text-book description. In practice these three muscles appear to form one system, through which the descending testis has thrust its way, carrying an abundant covering of muscle-fibres with it. The internal oblique and transversalis cannot be recognised as separate structures where they adjoin the inguinal canal, the conjoined tendon is not tendinous, and it is impossible to say where the lower border of this structure lies or where the cremaster begins. The differing origin of the two deeper muscles from Poupart's ligament appears merely as an overlaying of the cord as it emerges from the internal ring by their more superficial fibres. The cremaster is that part of the system which sweeps over the cord rather than gains insertion into the pelvis. If the conjoined tendon is unduly elaborated by descriptive writers, the cremaster receives insufficient attention. When this is carefully reflected in the inguinal canal of a healthy young man, it is found to be a well-developed muscle nearly $\frac{1}{8}$-inch in thickness which completely surrounds the cord (fig. 1986), not merely covering, but intervening between it and the fibrous posterior wall of the canal. The posterior wall of the inguinal canal is again a more real structure than text-book descriptions allow us to imagine. The transversalis fascia, elsewhere a thin membrane, is here a tough sheet which is firmly attached to Poupart's ligament and the ilio-pectineal line. Superficial to the fascia is a continuous sheet of muscle, the conjoined tendon medially, the posterior fibres of the cremaster laterally. The internal ring itself is no descriptive figment, but a strong fibrous opening in the fascial sheet, which in the undamaged canal has well-marked margins of considerable strength. On its medial side the deep epigastric artery forms a landmark, but is of no structural importance.

These anatomical points are all of importance when we come to consider the normal defences of the inguinal canal and the principles of repair when they have become effete. Any sub-division of the posterior

testis; the effaced segment can usually be traced as a fibrous band uniting the fundus of the sac to the summit of the tunica vaginalis. The retro-funicular and intra-funicular herniæ, grouped together as infantile, are of more uncertain origin. The explanation which is usually given in text-books, and the least likely, is that the funicular process is closed at the internal ring, remaining patent distally, and that an acquired sac is later pushed down behind it or into its lumen. Every stage intermediate between the funicular and retro-funicular varieties is met with, the tunica vaginalis extending up into the inguinal canal for varying distances in front of the sac, so that the infantile varieties are probably due to irregularities in the descent or obliteration of the

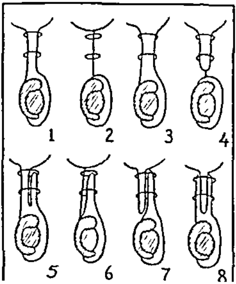


Fig. 1987.—Developmental abnormalities arising in the funicular process.

1. The funicular process just before birth
2. Normal closure of the funicular process.
3. Congenital hernia: a persistence of the condition seen in (1).
4. Funicular hernia.
5. Hernia magna.
6. Bilocular hydrocele.
7. Retro-funicular hernia.
8. Intra-funicular hernia.

vas deferens, from which it can be separated only with difficulty. In herniæ associated with imperfectly descended testes, this sheathing of the cord by the sac is so intimate as to render separation and closure of the peritoneal process a matter of real difficulty. The sac bears further traces of its congenital origin in numerous bands of fibrous, muscular, and nerve tissue which streak its outer surface, and in the occasional presence of small rests of adrenal cortex in its walls. In most cases the process of peritoneum is a simple tube. Occasionally the distal part is divided by septa into a series of compartments, which may be distended with fluid; incomplete septa and diverticula from the main channel are also found. These irregularities are in most cases of developmental origin, but they may be the result of pressure by a truss.

The extra-peritoneal fat usually ceases at the internal ring, and in the operation for hernia its appearance is an indication that the ring has been reached. The fat may, however, invade the cord, particularly in the inguinal canal of adults. Two conditions are seen: In one the fat extends down the cord distinct from the vessels and sac as a lobulated finger-like process carrying an obvious blood-vessel with it; in the other the fat is invaginated into the neck of the sac, and bears, when seen from the inside of its cavity, a very striking resemblance to a loop of small intestine protruding through the opening.

A direct hernia is merely a bulging of the posterior wall of the inguinal canal. This portion of the abdominal wall, when viewed from the inside, has been sub-divided artificially by Hesselbach's triangle, but this nomenclature is of no direct interest to the surgeon and of no particular significance. The portion which yields first is that which is formed by the transversalis fascia alone, that is, the part medial to the epigastric artery, below the arched fibres of the conjoined muscle, and lateral to their insertion into the ilio-pectineal line. The bulge is a general one, roughly hemispherical in shape, and the sac, which hardly merits such a name, has no obvious neck. It is covered by fascia throughout. As the hernia enlarges, it spreads upwards and outwards. The epigastric artery becomes arched over it, and in a larger hernia may appear to separate the swelling into a bilobed one. The lower fibres of the conjoined muscle and the cremaster become stretched, and the external aponeurosis becomes thinned. A direct hernia does not come through the external ring in the sense that an indirect one does, but when increasing in size it finds less resistance in the intercolumnar fibres than in the more fully developed parts of the aponeurosis, and may well

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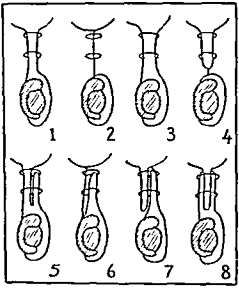

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funicular process, and have no acquired element. The distinction is of academic interest only, and affects neither the diagnosis nor the treatment of these herniæ, unless the possible confusion of an inexperienced surgeon on finding two serous cavities be taken into account.

The testicle is formed in the lumbar region, descends during fœtal life behind the peritoneum of the posterior abdominal wall and iliac fossa to the internal ring, and then traverses the abdominal wall, taking its vessels with it and maintaining the same relationship to the peritoneum which has preceded it into the scrotum. The sac of a congenital hernia therefore lies in front of the cord, or rather surrounds it in front, above, and below, so that in transverse section it shows as a horseshoe-shaped slit into which the cord is invaginated, much as the testicle appears to be [illegible] into the tunica vaginalis. The sac is [illegible] to [illegible] of the cord, and particularly to the

vas deferens, from which it can be separated only with difficulty. In herniæ associated with imperfectly descended testes, this sheathing of the cord by the sac is so intimate as to render separation and closure of the peritoneal process a matter of real difficulty. The sac bears further traces of its congenital origin in numerous bands of fibrous, muscular, and nerve tissue which streak its outer surface, and in the occasional presence of small rests of adrenal cortex in its walls. In most cases the process of peritoneum is a simple tube. Occasionally the distal part is divided by septa into a series of compartments, which may be distended with fluid; incomplete septa and diverticula from the main channel are also found. These irregularities are in most cases of developmental origin, but they may be the result of pressure by a truss.

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bulge through this without, however, reaching the scrotum. While any classification of types of direct hernia is unnecessary, it is advisable to point out that a rare variety, unmentioned in text-books, is occasionally encountered in which the posterior wall of the inguinal canal medial to the deep epigastric artery shows a small circular deficiency with firm, almost tendinous margins, through which a tubular process of peritoneum, indistinguishable on clinical examination from an indirect inguinal hernia, escapes and often emerges through the external ring. Whether such a hernia is of congenital origin, due to some trauma, or caused by a localised extra-peritoneal lipoma which weakens the fibrous sheet at one spot. is undetermined.

The sac of any inguinal hernia, as it enlarges, tends to draw further peritoneum from that lining the abdominal parietes into its walls, and with the peritoneum any mobile intra-abdominal structure which it clothes. Thus the bladder may be drawn into the neck of the sac on the inner side, the cæcum into the posterior wall of a right hernia, and the iliac colon into a left one.

THE DIAGNOSIS OF INGUINAL HERNIA

Any detailed account of the methods of clinical investigation of the inguinal canals would be out of place in a book addressed to post-graduate students, who may be presumed to have had considerable experience in the examination of patients before they come to study the details of operative surgery. Inspection should never be omitted, for a small hernia is often better seen than felt; this is particularly true of bubonocele in women and small children, where in a small sac the overlying fat often obscures the impulse on coughing; inspection, too, is often the most certain method of distinguishing a definite hernia from the common condition of bulging groin seen in feeble and sedentary men, where the whole inguinal region seems to come forward against the hands when the patient coughs.

The differentiation between an indirect and a direct hernia is often difficult, and sometimes impossible. It is not of major importance, for the type of large wide-mouthed hernia in which distinction is hard usually needs an operation, one which involves some form of plastic repair of the canal, and the exact relations of the swelling will therefore become apparent when the tissues are exposed. Direct herniæ are usually seen in men over forty: they are bilateral and symmetrical in size and position. A hernia which appears as soon as the patient stands without any straining effort, and which disappears as soon as he lies down without any pressure applied, or which, when reduced, returns

immediately, is probably direct; one whose length exceeds its breadth, or which comes anywhere below Poupart's ligament or medial to the pubic spine, is probably oblique.

The differential diagnosis between inguinal hernia and other inguino-scrotal swellings again seldom arises. Ordinary common sense will serve to distinguish swellings superficial to the abdominal wall, such as enlargement or abscess of the inguinal glands, or those deep to it, in the psoas or iliac vessels, from swellings in the inguinal canal proper. These must arise from some structure in the spermatic cord, and are either tumours—lipoma or fibromyoma—or varicoceles, or abnormalities in the mechanism of testicular descent—retained testes or hydroceles of the cord. A lipoma is softer than a hernia and gives no impulse on coughing, but unless accompanied by a sac, it rarely attains sufficient size or gives trouble enough to attract the attention of the patient. A fibromyoma forms a firm rounded swelling, which can only be distinguished with certainty from an encysted hydrocele by the absence of translucency. A varicocele can never be mistaken for anything else, unless one of the varices has ruptured.

A public schoolboy was seized with sudden pain in the left groin during a game of Rugby football, and was carried off the field and taken to the school sanatorium. A rounded swelling occupying the inguinal canal and extending through the external ring into the scrotum was found by the school doctor; it was tender, irreducible, gave no impulse on coughing, and was not translucent. A strangulated inguinal hernia was suspected, but as the boy complained of no abdominal pain and his bowels were opened by an enema, he was merely kept in bed and the pulse recorded every four hours. By next morning the left half of the scrotum was black, and it was clear that the swelling was a hæmatoma inside the infundibuliform fascia.

An encysted hydrocele of the cord is more often diagnosed than seen. The true encysted hydrocele is a small rounded translucent swelling, sharply demarcated at both ends, which is seldom encountered after the age of puberty. The majority of rounded translucent swellings in the inguinal canal are encysted hydrocles of a hernial sac, whose neck has become blocked by a plug of omentum; examination of the neighbourhood of the internal ring, where the cord is found to be thickened, will reveal their true nature.

LOCAL ANÆSTHESIA FOR HERNIA

The method of local anæsthesia is nowhere more valuable than in the surgery of hernia. Here operation must on occasion be undertaken for pain, increase of size in spite of a truss, irreducibility or threatened strangulation, in patients whose age or general condition would

prohibit such a step, were it not for the certain and greater risk of the imminent complication. Most of the risks are eliminated by a local anæsthetic; bleeding is minimal, and time sufficient for the most elaborate plastic procedures, should they be required, is afforded to the surgeon.

The nerves which must be blocked for an operation on the inguinal canal are many: The skin of the groin is supplied by branches of the 12th dorsal, 1st lumbar, external cutaneous and genito-crural nerves, that of the scrotum by the ilio-inguinal, scrotal branches of the internal pudic, and the long pudendal from the small sciatic; the abdominal muscles and peritoneum are innervated by the ilio-inguinal and ilio-hypogastric nerves, and the cord and testis receive their sensation from

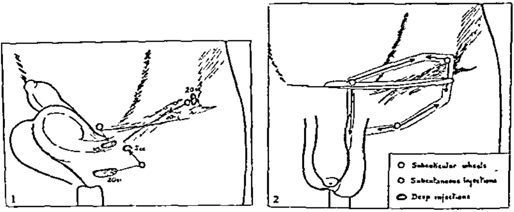

Fig. 1988.—LOCAL ANÆSTHESIA FOR INGUINAL HERNIA. (For details see text.)

the spermatic nerves accompanying the vessels. The plan outlined may be relied upon to give complete anæsthesia lasting for two hours.

The solution recommended is:

Novocaine	1 %
Quin. and Urea Hydrochloride	¼ %
Adrenalin $\frac{1}{1000}$	1 drop to 10 cc.
Normal saline to required amount.	

Three subcutaneous wheals are raised with a fine needle, one a finger's-breadth medial to the anterior superior spine, one over the saphenous opening, and one over the suprapubic skin crease in the mid-line (fig. 1988). A 3½-inch needle is inserted vertical to the skin through the first wheal, and 20 cc. are injected into the muscles, the point of the needle being pushed down during injection till it strikes bone; this injection will block the ilio-inguinal, ilio-hypogastric and last dorsal nerves. The needle is then withdrawn from the muscles, and pushed again through the external oblique aponeurosis, and a further 10 cc. are

injected deep to the aponeurosis in a direction towards the pubis. The needle is next inserted through the second wheal, and 20 cc. of solution are injected along the base of the scrotum which is held up, to block the scrotal nerves. Withdrawn slightly, its point is then pushed to the pubic spine, and 5 cc. are injected here. Through the third wheal a line of subcutaneous injection, 15 to 20 cc. in all, is put in along the skin crease, extending an inch across the mid-line and outwards to beyond the anterior superior spine. Still using the same wheal, 10 cc. are injected into the cord, which is held up for the purpose. Lastly, a continuous line of subcutaneous injection, using about 40 cc. in all, is placed around the whole area, uniting all three wheals, and passing from that in the mid-line beside the penis and down the mid-plane of the scrotum. If the injection is made before the surgeon puts on his gown and gloves for the operation, complete anæsthesia will be assured by the time he is ready.

THE GENERAL PRINCIPLES OF OPERATION UPON INGUINAL HERNIA

Any surgeon who attempts a survey of the literature of inguinal hernia approaches an almost impossible task, for very few men appear able to pass from qualification to retirement without describing a new operation for the cure of this condition. In a work intended to assist the post-graduate student, the writer must confine himself to an account of what he considers to be the essential principles of surgical treatment, and must accept responsibility for the selection of those principles. An analysis of the cure statistics from different clinics is likewise impossible without taking up much more space than the value of such an analysis would justify. In general it may be said that close upon 100 per cent of cures should be expected after operations upon inguinal hernia in children, about 95 per cent after operations upon oblique inguinal hernia in adults, and about 90 per cent after operations upon direct hernia. It is often stated that the commonest reason for recurrence is sepsis in the wound; but surely no surgeon of experience is convinced by this statement? Sepsis enforces prolonged rest and calls forth an abundant reaction of repair; induced sepsis was the basis of the mediæval treatment by blistering and is probably the modus operandi of the "modern" treatment by injection. Could it be controlled, it would be the reparative surgeon's best friend. It is common experience, in any case, that the majority of the recurrences encountered lie under beautiful linear scars. In the writer's opinion, failure is usually due to the operation being done by the wrong surgeon or by the wrong method. The anatomy of the inguinal canal is more

complex than that of any other part of the abdominal wall, and the repair of its defects calls for far greater skill than does the closure of a laparotomy wound. Yet hernia operations are rarely considered important. They are lightly undertaken by men who are not surgeons at all, and who refrain from attempting any other abdominal procedures. In hospitals they are often regarded as introductory exercises for the novice, and are left by the chief to his assistant when he has finished the more interesting part of his list. It is well known that even enormous and old-standing herniæ can be cured by an appropriate method skilfully performed; does it not follow then that when a simple hernia recurs the operation for its cure has either been inappropriate or imperfectly done? Chief among such technical reasons for recurrence are failure to remove the sac at its neck, failure to close the canal at its commencement, and damage to the natural safeguards of the canal. The neck of the sac and the opening in the transversalis fascia which constitutes the internal ring lie under cover of the origin of the internal oblique muscle, and they are not seen, much less efficiently treated, in any method which does not include full exposure of the inguinal canal and retraction of the internal oblique; yet exposure and ligature of the sac through the external ring, or through a small incision over the middle third of the canal, is still recommended in text-books and practised by some surgeons. The writer's views upon the mechanism of the inguinal canal have been set forth in the section upon anatomy and physiology. The reader who accepts these, must also accept their corollary, that any damage to the muscular sphincteric mechanism of the canal, that is, to the conjoined muscle and cremaster, will not merely invite recurrence, but ensure it. Bassini first inculcated the importance of the exposure of the whole inguinal canal and isolation of the sac from the other structures of the cord right up to its neck, and so paved the way for better technique. His name deserves to be placed with that of all great leaders. But the measures he advocated for closure of the canal when the sac had been removed are a useless mutilation of beneficent structures that can only be excused by the date of their introduction. That this barbarism should have survived into an age when all other pioneer operations have been refined and perfected by constant thought and care, and that it should still be universally taught and widely practised, is an indication of the scant attention paid to the inguinal canal by men engrossed in more dramatic regions, and a blot upon modern surgery.

There is no particular technique involved in the operation for hernia beyond that which is common to good surgery in any part of the body,

the creed of gentleness which is associated with the names of Halsted, Lane and Moynihan. Each plane must be divided along anatomical lines, the tissues must be treated with the greatest gentleness, hæmostasis must be complete, obliteration of dead spaces absolute and asepsis faultless. The inguinal region, where the abdominal wall surmounts the extraordinarily difficult task of transmitting the nerve and blood supply not only of the testes but of the lower limb, while permitting free movement and powerful stresses in the muscles and great variation in the diameter of the blood-vessels, depends for its security upon a most delicate adjustment of muscular and fibrous planes. The operative handling of this region should be correspondingly delicate, and inguinal technique is more akin to that of the plastic surgeon than of the worker in the more simple department of the upper abdomen. I know more than a hundred surgeons whom I would cheerfully allow to remove my gall-bladder, but only one whom I should like to expose my inguinal canal.

The essential question that must be answered, in deciding upon the type of operation to be undertaken in any particular hernia, is "Can the normal mechanism of the canal be kept in this case, or must it be replaced by something different?" The normal mechanism embraces fibrous and muscular elements; the former can, to some extent, be repaired if damaged; the latter cannot. Operations for the radical cure of inguinal hernia may therefore be placed into three groups, according to the object they seek to attain:

I. *The standard operation for congenital oblique inguinal hernia* where the muscle defences are good and the fibrous framework unstretched. Here removal of the entire sac without damage to muscular or fibrous tissues, and accurate reconstruction, will ensure success.

II. *Operations for larger inguinal herniæ of the oblique type*, whether congenital or acquired, where the muscles are still good, but the margins of the internal ring have become stretched. In these, after removal of the sac, some plastic procedure upon the posterior wall, designed to strengthen it where weak and to restore the diameter of the internal ring to that of the cord, will probably be satisfactory. The inguinal muscles themselves must not be used for this repair, or damaged in any way.

III. *Operations for direct or large oblique herniæ* where the fibrous tissues are stretched and the muscles atrophied. Here there is no likelihood of the weakened muscles regaining their sphincteric

action, and a new mechanism, foreign to the body, but perfectly satisfactory if well planned and carefully executed, must be devised. Such operations usually involve the construction of new internal and external rings, rigid and placed far apart, and of a strong fibrous anterior and posterior wall to the canal. The muscles are necessarily used in such an operation, but they cannot, without further reinforcement, provide a sufficiently strong sheet to prevent recurrence.

I. The Standard Operation

(1) *The skin incision.* For the reasons given in the section devoted to the anatomy of the inguinal region, an incision in the suprapubic skin crease is advised for all operations for the radical cure of inguinal

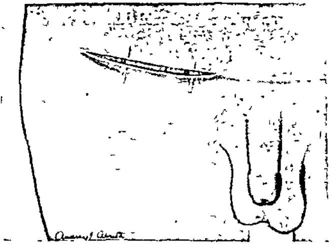

Fig. 1989.—Standard operation for inguinal hernia. The incision.

hernia. After identification of the crease, two light scratches are made across it with the back of the knife, to ensure accurate spacing of the flaps when they are subsequently sutured (fig. 1989). The cut should be made with a continuous sweep of the knife, while the skin is put on the stretch with the finger and thumb of the left hand, and should extend in the crease from a point ¾-inch outside Poupart's ligament nearly to the mid-line. In the wound, which is thus made to gape, the two branches of the superficial femoral vessels will be seen immediately, and should be divided between artery forceps, and ligatured with fine catgut. The surgeon then grasps the mid-point of the lower skin flap with toothed dissecting forceps and pulls it upwards, while his assistant does the same with the upper flap. A bold sweep with the knife through the superficial fascia, which is thus drawn strongly from the abdominal wall, will immediately lay bare the areolar plane between fat

and external oblique aponeurosis. The correct plane exposed, the surgeon quickly reflects the fatty layers off the external oblique, *downwards as far as Poupart's ligament, and upwards and outwards to* one inch beyond the internal abdominal ring (fig. 1990). Dissection with the knife should not be carried down to the external ring, as many small vessels pierce the intercolumnar fascia and are difficult to secure if divided; when the aponeurosis is cleaned so far, a downward sweep with a gauze swab will display the pillars of the ring and the emerging cord. Poupart's ligament should be laid bare at this stage down to its insertion, in order to facilitate subsequent suture of the pillars.

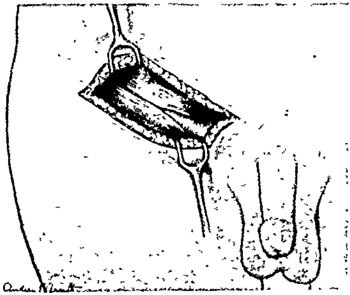

Fig. 1990.—STANDARD OPERATION. REFLECTION OF THE SUPERFICIAL FLAPS.

(2) *Reflection of the external oblique aponeurosis.* The external oblique should be incised towards the external ring and not from it, as this method carries a risk of injury to the cremaster or ilio-inguinal nerve. A cut about half an inch long is made with a knife in the aponeurosis in the line of the pillars, and about $\frac{3}{4}$-inch from the point where they diverge. The upper leaf is held up with dissecting forceps, and the cut extended with Mayo scissors into the external ring, and carefully beyond it into the intercolumnar fascia; the cut is then extended outwards in the line of the fibres to a point one inch above the internal ring.

The upper leaf is then reflected off the underlying structures, which are gently detached from its deep surface with sweeping strokes of the closed Mayo scissors, working from above down in the line of the arched fibres of the internal oblique (*fig. 1991*). Separation is continued till the outer border of the rectus sheath is exposed. The lower leaf is treated in a similar manner, till the inner surface of Poupart's

ligament is cleared as far as its insertion into the pubic bone; the fibres of the cremaster will be separated where they lie in contact with the aponeurosis, but their origin from Poupart's ligament must on no account be disturbed. When this stage is complete, the cord will be seen completely clothed in the fibres of the cremaster muscle on the surface of which lies the ilio-inguinal nerve.

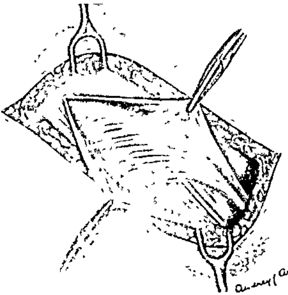

FIG. 1991.—STANDARD OPERATION. REFLECTION OF THE EXTERNAL OBLIQUE APONEUROSIS.

(3) *Reflection of the cremaster muscle.* The surgeon picks up the cremaster muscle with toothed dissecting forceps half an inch below the ilio-inguinal nerve and directs his assistant to do the same a quarter of an inch below it. A bold cut with Mayo scissors into the fold thus raised will open the sub-cremasteric areolar space. The closed points of the scissors are pushed up and down in this space to clear the cord, and the muscle is then divided in the line of its fibres, downwards to the centre of the external ring, and upwards to within a quarter of an inch of the arched fibres of the internal oblique. The surgeon now releases the lower leaf of the cremaster and, picking up the cord with his forceps, frees it by a few gentle touches of the closed Mayo scissors from the upper leaf of muscle, which is still held by his assistant (fig. 1992). The assistant then releases this leaf and takes the cord, while the surgeon picks up the lower muscular sheet and separates it in a similar manner. The cord is now free, and can be hooked up on the forefinger of the left hand, while the cremaster is pushed backwards from its two extremities with a gauze swab. The cord ly[illegible] the finger is covered with infundibuliform fascia only, and [illegible]stituents, normal or abnormal, can be clearly seen.

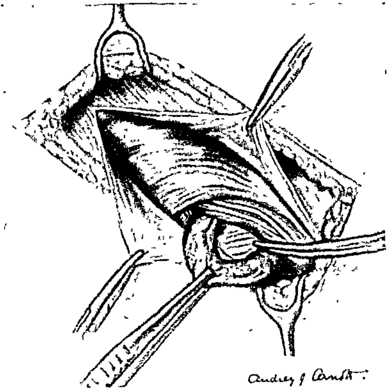

Fig. 1992.—Standard operation. Reflection of the cremaster muscle from the cord.

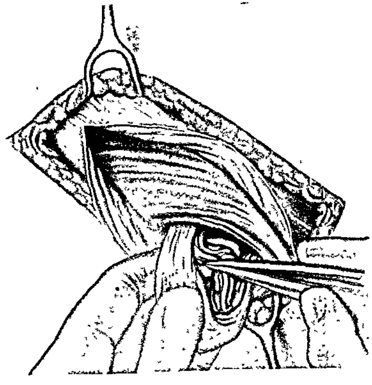

Fig 1993.—Standard operation. Isolation of the sac from the cord bundle.

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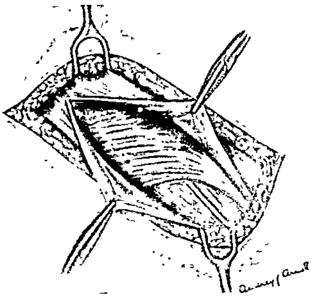

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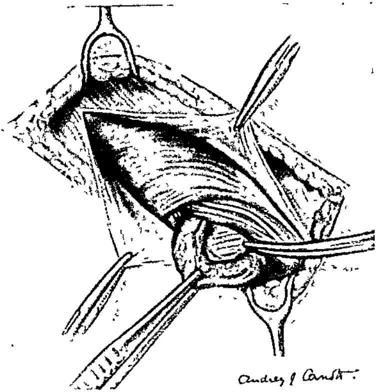


Fig 1992.—STANDARD OPERATION. REFLECTION OF THE CREMASTER MUSCLE FROM THE CORD.

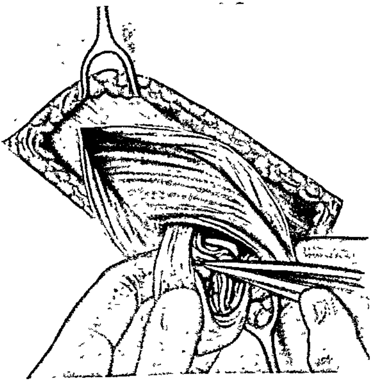


Fig. 1993—STANDARD OPERATION. ISOLATION OF THE SAC FROM THE CORD BUNDLE.

(4) *Isolation and ligature of the hernial sac.* The cord, still held up by the left hand, is incised longitudinally for about 1½ inches by a gentle stroke of the knife, which divides the infundibuliform fascia only. The sac, which has already been seen lying anteriorly in the bundle, now prolapses through this cut, completely denuded in its superficial aspect. It is picked up with a pair of Spencer Wells forceps which are then fixed by the thumb of the left hand, and thus held firmly on the pulp of the left index finger. With a pair of non-toothed dissecting forceps, all structures adhering to the sac are gently separated from it, working transversely to its long axis (fig. 1993). As succeeding parts of the sac are laid bare, they are gathered up with the left thumb, bringing a fresh portion into view for clearance. Finally, the point of commencement will be reached, and the index finger will be seen in a space which separates the sac from the cord. If the plane of dissection has been kept close to the wall of the sac, there is no danger of the vas deferens having been left attached to it, but the surgeon should always assure himself at this stage, by feeling the cord, that the vas is actually with the vessels and not with the sac. This dissection once begun must be pursued methodically in a plane transverse to the axis of the cord till two separate bundles emerge—the sac and the normal constituents; the left thumb must not relax its grip on the sac, and the temptation to wander up or down the cord must be resisted.

The vas and the vessels are kept in one bundle by enclosing them in the loop of a pair of Lane tissue forceps, and separation of the sac is continued towards the fundus in a similar manner, the sac being fixed by the left hand and the other structures peeled off it with blunt dissecting forceps. At the fundus some difficulty may be encountered. The tunica vaginalis is often continued upwards to a point which extends to the external ring and is adherent over a wide area to the expanded and flattened termination of the sac. The veins, increasing in size as the testicle is reached, are also firmly adherent to it, and the vas may lie in a loop on its walls, deviating from its previously straight course. Many of the bands are so tough that they must be cut by the knife. By working gently and methodically, holding the cord on the stretch and pushing its constituents from the sac with gauze and closed scissors, and using the knife only for strands that stand out clearly between structures already isolated, the separation will be effected without damage or bleeding.

When the fundus is free, the assistant draws the cord downwards and inwards, putting it on the stretch, and the surgeon, drawing the sac outwards, proceeds to clear its neck. The vas and veins are clearly

seen and easily separated by strokes with the closed scissors. The fibrous sheath should here be treated with great respect, not torn apart, but snipped with scissors close to the sac. As the neck is reached, a small retractor must be inserted under the upper leaf of the cremaster, drawing this muscle and the lower fibres of the internal oblique upwards and outwards. In an undilated sac the site of the neck can be recognised *without difficulty; its diameter expands suddenly*, the peritoneum becomes thinner, a tongue of extra-peritoneal fat appears beside it, and the deep epigastric vessels are seen below it. Except in those very thin sacs whose emptiness can be seen without any doubt, the fundus should now be cut and held open with three forceps, the interior of the

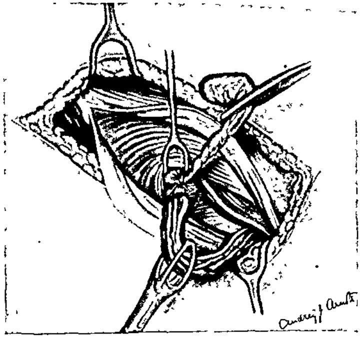


Fig 1994.—Standard operation. Twisting and ligature of the neck of the sac.

tube inspected, any contents returned, and a blunt instrument passed through the neck into the peritoneal cavity to prove that *no contents* are adherent at the neck. The cut fundus is then grasped in the jaws of *one pair of artery forceps, and twisted repeatedly, till the turns* reach the internal ring (fig. 1994). This torsion of the sac serves two purposes: it obliterates the whole cavity and ensures that no loop of gut or tag of omentum can enter at the last minute and be pierced during transfixion of the sac, and it provides a narrow pedicle for ligature. The sac is held up while its twisted neck is pierced with a round needle carrying No. 1 catgut and tied, first on one side, then on the other, and finally all round in the groove made by the first two knots. The ligature is cut and the sac divided half an inch beyond it; the stump recedes immediately behind the aperture in the transversalis fascia and disappears from view.

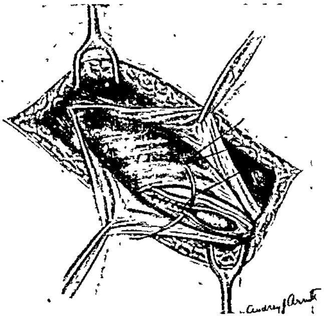


Fig. 1995.—STANDARD OPERATION. REPAIR OF THE CREMASTER MUSCLE.

(5) *Repair of the inguinal canal, and closure of the wound.* When the neck of the sac has been cut and the surgeon has satisfied himself, by gentle palpation, that the internal ring is unstretched, the layers are closed in sequence.

The cord is pushed down into the scrotum till it lies level with the floor of the canal, and the cut edges of the cremaster muscle are picked up near the internal ring. A continuous suture of No. 00 catgut on a fine round-bodied needle will serve to unite this layer over the cord (fig. 1995). The fibres have not been cut across and the sutures require no more tension than is necessary to approximate the edges of the cut. Care must be taken that the ilio-inguinal nerve is not caught up.

The external oblique aponeurosis is sutured with No. 1 catgut on a round-bodied needle, starting at the lateral end of the wound. As the inner end is approached it is important to make sure that each stitch takes a bite of the firm fibres constituting the pillars, and not merely of the thin expanded aponeurosis that lies between them (fig. 1996). The suture should be continued inwards till the external ring is reduced to a size that will just transmit the cord comfortably—that is, to the diameter of the last joint of the little finger; the last stitch should therefore be held tight, and the diameter of the ring tested before it is finally tied.

Accurate closure of the cutaneous layers is an important step in the crease operation for hernia. Three or four sutures of No. 00 catgut on fine, curved needles are passed in the following way: The needle is passed from the deep surface of the upper flap, traversing the fascia

of Scarpa and then that of Camper, to emerge close under the skin. It is re entered close under the skin on the lower flap at the corresponding point (which is identified by the skin scratches made before the operation was started) and passed down through the two fatty layers to emerge on the deep surface of Scarpa's fascia (fig 1996) These sutures, when tied, obliterate all dead space between the operation site and the flaps which cover it, evert and at the same time relieve the skin margins of tension, and carry their knots at the greatest distance from the skin, where they are almost immune from the "catgut ooze" that will often spoil a promising incision The skin is closed with Michel clips, the scratches being first brought together, after which the intervening spaces are approximated (fig 1997)

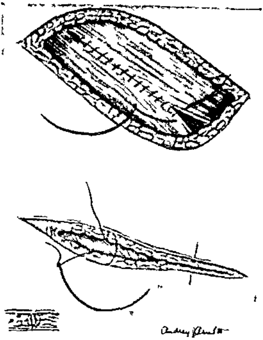
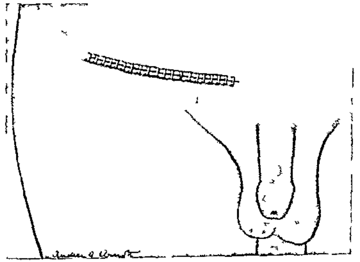


Fig 1996—STANDARD OPERATION
(*Top*) REPAIR OF EXTERNAL OBLIQUE APONEUROSIS
(*Bottom*) SUTURE OF THE SUBCUTANEOUS LAYERS

(6) *After-Treatment* The care of a hernia case differs little from that of any other operation of moderate severity, and any detailed instruction would be out of place Two points, however I consider important

First, that in the crease incision all clips should be removed in forty eight hours Where the incision has been placed in a plane of no

Fig 1997—STANDARD OPERATION CLOSURE OF THE INCISION



movement, and where the deeper layers have been brought together and the skin accurately apposed, clips or sutures are no more than approximating devices. Their retention after forty-eight hours serves *no purpose, and invites sepsis.*

Secondly, that the patient should remain in bed for three weeks. A good inguinal canal after a hernia operation demands fibrous planes reconstructed by repair tissue which has been subjected to no premature strain. The patient may, after forty-eight hours, assume any position in bed that he likes if his general condition warrants it, but recumbency should be insisted upon.

Alternative incision. That commonly employed is a straight incision, parallel to Poupart's ligament and about half an inch above it, extending from a point ¾-inch outside the internal ring to one overlying the centre of the external ring. This is shorter than the crease incision and gives more direct access, and will be preferred by the surgeon who is inexperienced, badly assisted, or otherwise working under difficulties.

Alternative methods in isolating the sac. Many text-books describe, and many surgeons practise, a search for the hernial sac as soon as the external oblique aponeurosis has been reflected. It is quite possible to isolate a hernia in this way, but not easy, for the cremasteric fibres hide the structures which they still envelop, nor wise, for a muscle which has been avulsed as an obstruction to vision will never regain its normal function.

SPECIAL POINTS IN THE ISOLATION AND LIGATURE OF THE HERNIAL SAC

(1) *The separation of a very thin-walled sac.* In some inguinal herniæ, particularly the complete congenital herniæ of children which extend into the tunica vaginalis, and those associated with an undescended testis, the walls of the sac are extremely thin and fragile, and adherent to the structures of the cord to an unusual degree. In spite of the greatest gentleness, the peritoneum is torn in an attempt to strip the vessels from it. The margins should then be seized with hæmostats, and the attempt continued. If further tears appear, the surgeon may allow the sac to gape, and, guided by vision, gently work the point of a blunt dissector or one blade of a pair of dissecting forceps between the peritoneum and the cord. When the correct plane has been established at one level, the sac can then be stripped up and down with a little care.

In some herniæ even this manœuvre will fail. It has been my

practice in such cases to open the sac with scissors on its anterior aspect to within half an inch of its neck, and to get my assistant to hold the margins apart in mosquito forceps while he makes traction on the cord. The neck of the sac, now seen from within as a small funnel, can be cut round with the point of a fine knife or with Mayo scissors, the cut extending through peritoneum only, and each segment be picked up with a further pair of mosquito forceps as it is divided. When the peritoneum has been divided all round the neck, the forceps are held up together, the neck cleared from the cord by a few strokes of the closed scissors, and tied off. It is unnecessary after this to remove more of the body of the sac than its anterior wall, which should be cut away freely, leaving the posterior wall still clothing the cord.

(2) *The treatment of the tunica vaginalis in congenital hernia.* Where the hernial sac is continuous with the tunica vaginalis, there is no "fundus" in the sense of a rounded termination that can be removed in continuity with the body. The surgeon may either carry the separation of the sac to the upper pole of the testis, and there divide it, closing the distal half with a simple ligature or a purse-string suture, to leave a tunica vaginalis; or he may carry his dissection into the scrotum and remove the parietal layers of the tunica vaginalis with the sac—combining a "radical cure" of hydrocele with that for the hernia. The choice will depend ultimately upon the operator's personal views upon the inevitable wisdom of all Nature's handiwork. The tunica vaginalis is a normal structure and must serve some purpose; on the other hand, a hydrocele is perhaps slightly more common after a hernia operation than it is in the average population, and removal of the outer serous layers does not seem to carry any recognisable disability. I personally reconstruct the tunica vaginalis in the child, and obliterate it in the adult.

(3) *The removal of lipomata.* Any lipomata lying in the inguinal canal should be removed as part of the operation of radical cure. They stretch the muscles, interfere with efficient action of the sphincteric mechanism and, when springing directly from the extra-peritoneal fat, undoubtedly lead to recurrence by dragging down a fresh pouch of peritoneum. Such lipomata are preferably removed as soon as the reflection of the cremasteric layer is complete, and before the sac is disturbed; they can then be seen clearly and removed completely, whereas later they are stained with blood and are less distinct. The pedunculated lipoma which passes through the internal ring beside the sac should be crushed and ligatured before it is divided.

(4) *Other means of treating the neck of the sac.* Various surgeons

have used the sac itself as a material for reinforcing the region of the internal ring. Macewen passed a catgut suture through the fundus of the sac, and then from side to side through its body, so that when pulled tight it drew the sac into concertina folds; the free ends of this suture were threaded on a hernia needle and passed upwards through the internal ring lateral to the sac, being finally pushed through all muscular layers about an inch lateral to this point and tied on the surface of the external oblique aponeurosis. Kocher grasped the fundus of the sac with a pair of curved forceps and invaginated it, forcing the end of the forceps through the parietes lateral to the internal ring; here the redundant part of the sac was cut off, and the stump stitched to the parietes. These operations are of little more than historical interest to-day. Such dislocation of the sac does not ensure the smooth unbroken peritoneal surface on the abdominal aspect of the inguinal region which is attained by ligature of the sac at the correct level, while it damages the fascial planes of the internal ring and the muscles above this to no real purpose. Ligature of a sac which has been isolated to its commencement with the greatest gentleness, and divided half an inch beyond the ligature, will leave a smooth peritoneum, backed up by an undamaged fascial layer, and reinforced behind the peritoneal scar by a fibrous plug.

INGUINAL HERNIA IN THE FEMALE

The female inguinal canal follows the same general arrangement as the male, with such modifications as are dependent upon its differing contents. The round ligament is smaller and less vascular than the cord, and is not subjected to the same movements and alterations in diameter. The channel is therefore smaller, the cremaster inconspicuous, and the conjoined muscle forms a less obvious arch, running close above and almost parallel to Poupart's ligament. Inguinal hernia in the female is nearly always due to the persistence of a congenital sac, and this sac is usually blended with the round ligament and extends well into the labium majus. To separate the sac from the round ligament without damage to either structure is a difficult and tedious matter, and in the opinion of the majority of surgeons unnecessary. The round ligament curtailed at the internal ring can apparently carry out its suspensory functions with regard to the uterus, whatever they may be, as efficiently as when it is continued into the labium.

The steps of the operation are identical with those of the standard repair in the male, down to the stage when the cremaster is reflected

from the round ligament. The sac and round ligament are now held up together on the index finger of the left hand, and pulled gently while their distal extensions are cleared from the tissues in the labium by blunt dissection. When the fundus of the sac has been brought into view, any remaining strands of tissue, including the termination of the round ligament, may be clamped, tied, and cut across. The round ligament and sac are now held up and cleared as far as the internal ring. The sac is usually so thin that it can be seen whether it is empty ; should there be any doubt, it should be opened for inspection and for the passage of a probe. This point settled, the sac-round-ligament bundle is crushed at the neck with Ochsner forceps, transfixed, tied with catgut, and cut across half an inch beyond the ligature. Since the canal is now empty, it should be obliterated by three sutures of No. 1 catgut, passed through the conjoined and cremaster muscles and Poupart's ligament, and tied sufficiently tightly to approximate but not to cut into the muscles.

II. The Standard Operation, as Modified for Larger Herniæ of the Oblique Type

The standard operation just described is that which offers the best chance of permanent cure in an oblique hernia where the muscular defences are intact, the fibrous posterior wall of the canal sound, and the internal ring unstretched. Many cases are met with, however, in which the internal ring has become damaged while the remainder of the mechanism of the canal remains comparatively sound. The neck of a congenital oblique hernia lies above and to the outer side of the cord, and in its early days represents a potential space only, which does not dilate the fibrous collar of the internal ring. With the repeated entry of abdominal contents into the sac, and particularly with their lodgment there, the ring becomes stretched to accommodate cord plus sac. To start with, the stretching is in that part of the circumference occupied by the sac, that is, the upper and outer segment, and the *inner border of the ring is not displaced.* With time, however, the whole ring becomes dilated, the inner border, and with it the deep epigastric artery, is displaced medially, and the cord, though still bearing the same relation to the neck of the sac and the artery, leaves the posterior wall much nearer the mid-line than is normally the case.

These observations have an important bearing upon the steps necessary for the repair of the internal ring. Estimation of the size, degree of shift, and strength of the borders of the ring is more easily made by touch than by sight. The size of an unstretched ring is the

diameter of the cord when engorged with blood, roughly that of the last joint of the little finger. Such a ring requires no repair. If the surgeon finds that the site where the sac has been tied and cut off appears as a weak area lying outside the cord, but that the cord is not displaced medially, that the inner margin of the ring is firm, and that the deep epigastric artery runs a straight course, he will be content with some simple approximation of the edges of the defect in the transversalis fascia over the stump of the sac. If, on the other hand, he finds that the ring as a whole is dilated, the cord displaced and the artery shifted, he can only restore normal relations by moving the cord outwards to

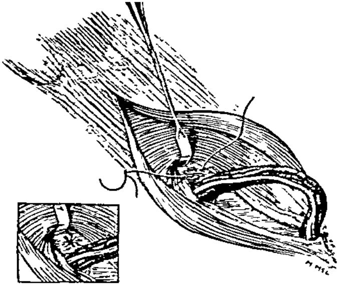


Fig. 1998.—Reconstitution of defect in internal ring: first method.

that part of the ring formerly occupied by the neck of the sac, and repairing the weak area to its medial side.

(1) *Simple suture of the defect in the internal ring.* The weak area must be exposed by drawing the cremaster and internal oblique muscles strongly upwards with a small retractor, thus bringing into view the transversalis fascia lateral to the cord, the stump of the divided sac, and the defect around it. The margins of the defect are defined by palpation and brought together by a stitch of No. 1 chromicised catgut, the needle taking a bite of firm fibrous structures. Two methods of closure may be recommended in these borderline cases:

(*a*) The Arbuthnot Lane "X" stitch (fig. 1998), which draws the edges of the defect over the peritoneal stump.

(*b*) A mattress stitch passed on a round-bodied needle, first through Poupart's ligament about half an inch lateral to the internal ring, under the conjoined muscle, to emerge at the ring, then

out through the upper margin of the defect and back through its inner margin, and then back under the muscles to pierce Poupart's ligament again about ¼-inch from its point of entry. This stitch, which is easily understood by reference to the diagram (fig. 1999), draws the margins of the defect together, and the whole weak area outwards.

(2) *Reconstruction of the internal ring.* After ligature of the sac, the cord must be displaced to the outer and upper part of the stretched ring, and held there by a retractor, which at the same time keeps back the muscles and exposes the inner part of the defect. The margins of

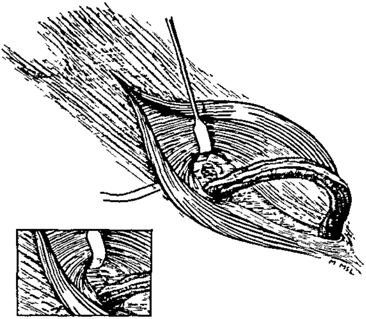


Fig. 1999.—Reconstitution of defect in internal ring: second method.

what should be the ring can be felt more easily than seen, but after identification they may be defined by careful snipping away of loose tags of fascia and muscle. It is essential that the repair material should be anchored at its edges to firm fascial tissue.

(*a*) *Silk reinforcement.* I personally prefer the use of silk to any other method, as it does not involve dislocation of, or injury to, any of the normal structures of the canal or its neighbourhood, it is rapid, easy, and atraumatic, and it forms the basis of a tough and permanent fibrous sheath. A length of No. 4 Chinese twist silk on a small, curved needle (the particular needles I use are small Symonds needles with the shank shortened to make them into a half-circle instead of fish-hook shape; these are sold by the Medical Supply Association Ltd., 95 Wimpole Street, W.1, as " Ogilvie No. 5 ") is passed through the inner margin of the

stretched ring previously defined, and through Poupart's ligament just below this, and knotted (fig. 2000). The short end is caught in a hæmostat. The silk is worked backwards and forwards across the weak area, taking alternate bites of ring margin and Poupart's ligament, and drawn tight enough to lie straight, but not to exert any tension. This darning is continued outwards till the ring is reduced to an opening which exactly fits the cord, lying well out and under cover of the internal oblique. The silk is then knotted on itself and continued back, taking bites of Poupart's ligament between the

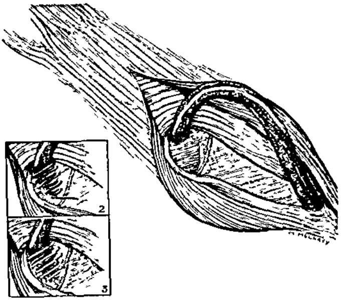


Fig. 2000.—Repair of internal ring by silk lattice.

1. The internal ring defined
2. First layer of silk.
3. Second layer of silk.

former stitches and of the transversalis fascia a few millimetres outside the ring margin. When the starting-knot is reached, the two ends of silk are tied together and cut short.

(*b*) *Fascial strip darning.* A repair, similar in all essentials to that described with silk, may be performed with one or two fascial strips. The strip may be taken from the fascia lata of the thigh with a fasciatome. Alternatively, a ribbon cut from the external oblique aponeurosis, and left attached at one or other end, may be used for the same purpose. I have used a strip cut from the upper leaf, left attached at its outer end, and brought to the internal ring through a tunnel in the muscles, arguing that such a strip would automatically become tense when the abdominal muscles contracted (fig. 2001). The belief that any isolated strip of muscle continues to act as

such is probably erroneous, but, at any rate, the repairs carried out by this method have stood the test of time.

(c) *Turner's operation.* Mr. Philip Turner repairs a badly stretched internal ring by turning up a flap of fascia lata from the thigh under Poupart's ligament and suturing it to the margins of the defect medial to the cord. Philip Turner (*Guy's Hospital Reports*, 1933, XIII, 2, 233) writes: "The essential feature of the operation is that a pedicled flap of fascia lata with its base at Poupart's ligament is used for the purpose of diminishing the size of the opening and strengthening the fascial boundary of the canal. The flap is turned upwards

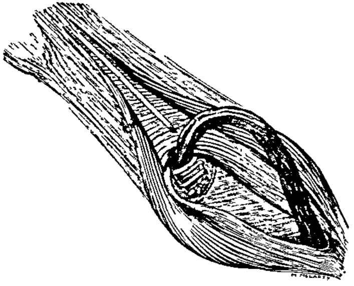


Fig 2001 —Repair of internal ring by pedicled strip of aponeurosis

beneath Poupart's ligament into the inguinal canal, and is sutured to the margins of the gap which have been carefully defined at an earlier stage. . . . The original deep surface of the flap, which was in contact with the muscles of the thigh, looks forward, while the original superficial surface, in relation with the fatty tissues of the thigh, is now in contact with the extra-peritoneal fatty tissue at the back of the inguinal canal." Reference to figure 2002 will explain the essential features of this operation.

In all of the above operations, the cremaster is carefully sutured over the cord, as in the standard operation.

III. Reconstruction of the Inguinal Canal

The operations hitherto described have been based upon the preservation or restoration of the normal inguinal mechanism. When,

however, this mechanism is beyond repair, something much more elaborate and drastic is required—the replacement of Nature's handiwork by that of man. The decision that such reconstruction is necessary is therefore one of considerable importance.

The defences of the inguinal canal are based upon a system common to the whole locomotor apparatus of the body—a fibrous framework protected by a muscular guard, much as the defences of a frontier consist of mechanical fortifications manned by living troops. Under repeated attacks the forts may be destroyed but the garrison remain effective, or forts and garrison may be overwhelmed together; but it is

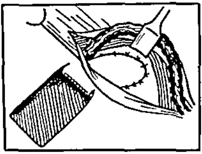


Fig. 2002.—Turner's operation.

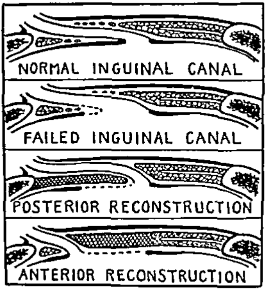


Fig. 2003.—Diagram to illustrate alternative methods of reconstructing the inguinal canal.

unlikely that the soldiers would be put out of action while the fortifications remain undamaged. So in the inguinal canal the fibrous planes alone may suffer, the muscles may atrophy with or after the fibrous planes, but the muscles cannot give way alone, leaving the fibrous tissues intact.

Reconstruction is necessary when the fibrous planes have yielded to such an extent that repair is impossible without encroaching on the muscles, or when, with a lesser degree of fibrous tissue damage, the muscles are also inefficient. Any yielding of the posterior wall itself, that is, of the part medial to the deep epigastric artery, is an absolute indication for reconstruction. Enlargement of the ring lateral to the deep epigastric artery is remediable if the stretching is moderate, the margins of the defect firm and defined, and the inguinal muscles good; but beyond a certain point, which for practical purposes may be taken

as a diameter of 3 cms., the enlarging ring encroaches to such an extent on the posterior wall that the failure becomes a general one of the fibrous planes of the canal. An estimation of the condition of the muscles is therefore of decisive importance only in those cases where the *fibrous defect is considered reparable provided the muscles can play* their part. Replacement of the fibres of the cremaster by connective tissue or fat, a general bulging of the conjoined muscle, or a pale flabby appearance of its fibres, will determine the surgeon to reconstruct rather than to restore.

The reconstruction of a failed inguinal canal would be simple were the surgeon given the relatively straightforward task of closing the whole defect, as he would an incisional hernia, and not the more complex one of providing sound repair while allowing free passage to the spermatic cord. Castration can only be considered in exceptional cases, while the expedient of reducing the diameter of the cord by excising the greater part of the pampiniform plexus, a step which formed part of the original Halsted operation, has been abandoned because of the unfortunate sequelæ—pain, hydrocele, and atrophy of the testis—which follow it in many cases. The problem has been approached in many ways, but the *suggested operations fall into two great sub-divisions: the operations* of repair anterior to the cord, and the posterior repair operations. The student himself must decide which type of repair is the more rational, and be guided in his decision by principles rather than by the "witch words" with which surgeons, hardly less than parsons and politicians, are prone to suggest the answer by the way they word the question. Advocates of anterior repair claim that the cord is not "dislocated" from its bed; the same men do not "dislocate" themselves or their patients from bed, and employ a word suggesting violent rupture from firm natural bonds, because they have already decided that they do not wish to reach the posterior wall of the canal. In my opinion the deciding factor is that surgical repair depends ultimately upon the production of firm fibrous tissue, and a fibrous channel transmitting a bundle of blood-vessels must be long and oblique to be secure. An efficiently performed posterior repair will transmit the cord through two openings, each rigid and of the required diameter, and placed far apart in strong anterior and posterior walls. Anterior repair, which takes no cognisance of the posterior wall, may make a rampart equally strong, but the channel which it leaves for the cord will eventually become a direct one, lying close to the pubic spine (fig. 2003).

I propose, therefore, to describe first the operation of posterior reconstruction, giving preference to those methods which I have

personally found satisfactory, and to follow those with a short description of other methods of posterior repair, and of representatives of the anterior method which are favoured by surgeons in many parts of the world.

(1) *Silk lattice repair of the inguinal canal.*

The reconstruction operation described is based upon the Gallie method of fascial suture, and the " darn and staylace " method, which was well described by Sampson Handley in the June 1918 issue of *The Practitioner.* The advantages and disadvantages of silk and fascia have been discussed on page 3610.

The preliminary steps are those of the standard operation described on page 3626. The skin-crease incision is advised, and, where silk is used, has the additional advantage that the early removal of sutures, and the divergence between the plane of the incision in the sub-

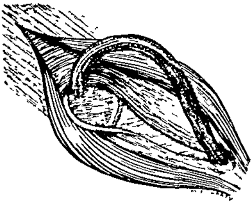


Fig. 2004.—POSTERIOR RECONSTRUCTION OF THE INGUINAL CANAL WITH SILK. FIGURE SHOWS THE INTERNAL RING STRETCHED AND THE EPIGASTRIC ARTERY DISPLACED MEDIALLY.

cutaneous layers and that of the musculo-aponeurotic structures, provide further safeguards against chance infection from without. The external oblique and cremasteric layers are divided and reflected in turn, and the cord lifted from its bed (fig. 2004). If the hernia is an oblique one, the sac is separated from the cord in the usual way, isolated to its neck, ligatured and cut off; if it is direct, the sac should, except for very special reasons, be left undisturbed. To excise the wide sac of a direct hernia adds nothing to safety, for such herniæ do not strangulate; it does not increase security, for it stretches thinned tissues still further: on the other hand, it may involve the risk of wounding the bladder, and in any case produces a scar on the peritoneal surface of the inguinal region.

The aim of the operation being to produce a uniform fibrous sheet protecting the whole posterior wall of the inguinal canal, and leaving only an aperture for the passage of the cord, it is first necessary to prepare the two ends of the canal (fig. 2005). At the medial end the

repair must extend down to the meeting-point of the insertions of Poupart's ligament and the rectus sheath on the body of the pubis. This point is covered and obscured by the fibres of the cremaster which sweep from the inguinal canal into the scrotum. It is therefore necessary to cut round the cord at this level with scissors, so that the muscle-fibres drop back into the inguinal canal and the cord itself remains bare: *a small artery in the cremaster usually requires ligature at this point.* At the lateral end of the canal it is necessary to reconstruct an internal ring lying at the periphery of the weakened one. The muscles are therefore retracted and the cord pushed to the outermost part of the stretched ring. If, in the case of a large oblique hernia, the ring has been so dilated that its outermost part cannot be reached by retraction, the internal oblique may be divided at its origin from Poupart's ligament for a distance of half an inch to provide access.

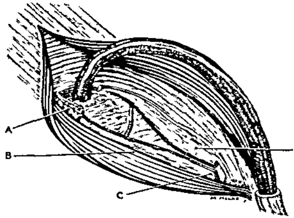


Fig 2005.—POSTERIOR RECONSTRUCTION. PREPARATION OF THE TWO ENDS OF THE FAILED INGUINAL CANAL TO ALLOW THE POSTERIOR WALL TO BE REINFORCED THROUGHOUT ITS LENGTH

A. INCISION OF INTERNAL OBLIQUE TO ALLOW THE END TO BE DISPLACED TO THE OUTERMOST LIMITS OF THE STRETCHED RING. THIS STEP IS NECESSARY ONLY IN THE WORST CASES.
B POUPART'S LIGAMENT
C AND D LOWER AND UPPER FLAPS OF CREMASTER CUT FREE FROM CORD TO ALLOW ACCURATE CLOSURE OF THE DEFECT AT ITS INNER END.

The lattice is constructed with a strand of No. 4 Chinese twist silk, boiled, soaked in $\frac{1}{1000}$ flavine solution, and threaded on a small curved round-bodied needle (see pages 3639 and 3640). Twenty-four to twenty-six inches are required for a complete reconstruction, but as such a length is unwieldy I usually work with an 18-inch suture and join another for the return layer. The first stitch takes a firm bite of the deep aspect of Poupart's ligament at its insertion into the pubic spine and of the conjoined tendon where it becomes anterior rectus sheath in the immediate vicinity (fig. 2006; see also fig. 2015); the silk is knotted and the short end caught with artery forceps. The cord is then held out of the way while the suture is continued in a lateral direction, taking first a bite of the recurved edge of Poupart's ligament, then of each side of the cremaster, then of conjoined tendon, and then back to Poupart's ligament. The stitches are placed about four to the inch, and are drawn tight enough to lie straight, but not to put any strain on Poupart's ligament or to pull it out of line. As the internal ring

is approached, the cord is held firmly outwards with the muscles, and the suture is continued till it can be felt that only an opening the size of the tip of the little finger remains below the arch of the muscles.

The next step is to reinforce the ring. The silk is knotted on the

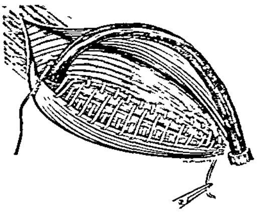


Fig. 2006.—Posterior reconstruction. Insertion of the first row of silk sutures.

conjoined tendon; then carried transversely across above the cord, passed through muscle and knotted again; then brought downwards to pick up Poupart's ligament lateral to the cord and once more

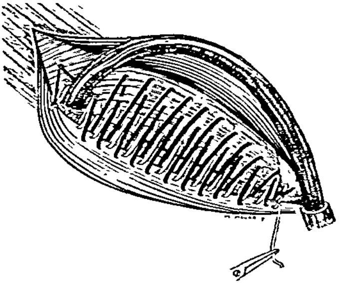


Fig. 2007.—Posterior reconstruction. Insertion of the second row of silk sutures.

knotted; the three stitches are then repeated in the reverse direction, being knotted at each angle so that the emerging cord is surrounded by a double ring of reinforcing silk.

The suture is now continued back to the inner side of the canal with a wider traverse, taking on the one side a bite of the free edge of Poupart's ligament between the stitches of the previous row, and on the

other the aponeurotic structures where the oblique muscles become tendinous at the outer border of the rectus (fig. 2007). As before, each stitch is pulled firm but not tight. When completed, the latticed area should present a definite resistance to the finger like last year's tennis racket, but the stitch holes should nowhere show any evidence of tension. At the inner end of the canal the free silk is tied to the first suture and both are cut short.

The cord is now laid back on its new bed, the external oblique aponeurosis repaired, with overlap if it has been much stretched, and the superficial layers closed in the manner previously described.

(2) *Gallie's operation.*

Gallie's investigations into the repair of fibrous tissues, and his description of the operation of fascial suture as applied to the cure of large herniæ, have probably had more far-reaching effects and been of greater benefit to mankind than any surgical discovery of this century. By the methods he so ingeniously devised, many men who would otherwise have been condemned to a life of restricted activity have been returned to full work and health. For personal reasons that I have attempted to explain on page 3611, I prefer silk to fascial suture in the inguinal canal; but the method of Gallie, here described, is used with satisfaction by surgeons in every country.

The preliminary steps of the operation will be identical with those described for silk repair; the subsequent ones may be quoted from the author's article. (W. E. Gallie and A. B. Le Mesurier, *Brit. Journ. Surg.*, 1924, XII, 46, 315–319.) "The first suture of fascia lata, a quarter of an inch wide, is anchored securely into the rectus sheath close to its attachment to the pubic bone. The needle is now passed behind the spermatic cord to pierce Poupart's ligament at its insertion into the pubic spine. If possible it should be made to pick up the periosteum to make the security of its fixation more certain (fig. 2008). When the suture is drawn taut, the weakest spot in the abdominal wall, namely, that which lies behind the external abdominal ring, is filled with a tough aponeurotic tissue which effectively prevents any bulging through the ring. The sewing is continued in an outward direction, drawing the internal oblique muscle to the reflected portion of Poupart's ligament behind the cord, until the position of the internal ring is reached. Here the suture is locked and then carried to the outer side of the ring, where a supporting stitch is inserted. In this way the cord, at the point where it disappears through the abdominal wall, is surrounded by a fibrous ring which will effectively prevent the development of a hernia at this point. By locking each stitch at this stage the

possibility of undue constriction of the cord is prevented. The sewing of the internal oblique muscle to Poupart's ligament in this manner is a detail of the operation which in our opinion is of very little value in preventing recurrence of the hernia. It is of value, however, in permanently covering the peritoneum with a thick layer of muscle which will prevent the protrusion of peritoneum through the chinks of the next layer of sutures, which is the important one in the prevention of recurrence. This layer commences as a continuation of the first,

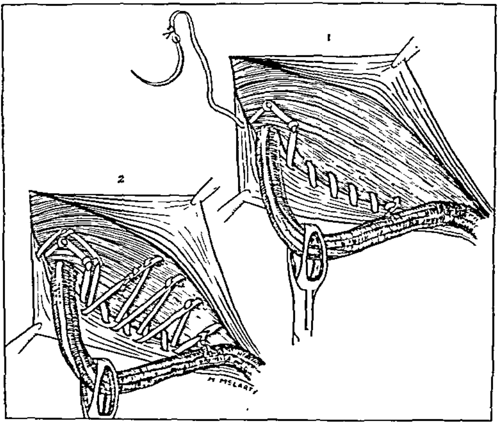


Fig. 2908.—Posterior repair of inguinal canal by Gallie's method.

at the outer side of the internal ring. The needle takes a solid bite of the abdominal aponeurosis at its point of fusion with the external oblique and is then passed behind the cord to pick up Poupart's ligament. *The suture is carried backward and forward across the space, with frequent lock-stitches, until the sheath of the rectus is reached,* and this also is woven to Poupart's ligament until the whole space is filled with fascia down to the pubic spine. No attempt is made with the second row of sutures to drag the abdominal aponeurosis and the rectus sheath out of their normal positions. No greater tension is exerted on the sutures than is sufficient to make them lie flat. The

whole idea of the operation is to fill the weak spot in the abdominal wall with what may be called a filigree of living aponeurosis, and to depend on the strength of this filigree and on its grip on the surrounding tissues for the cure of the hernia. What one does with the external oblique is of relatively little importance. Usually in direct hernia it is too weak to be of any value to the surgeon. In our earlier operations we closed it down to the external ring with a narrow strip of fascia, but in the last four years we have simply sewn it up with catgut."

(3) *Fascial repair by strips cut from the external oblique.*

Gallie's method of fascial suture may be carried out in suitable cases with strips ¼-inch wide cut from the upper and lower flaps of the external oblique aponeurosis. The strips are left attached at the pubic end, where they form part of the pillars of the external ring; their lateral end is divided where the aponeurosis joins the muscle-fibres, and is threaded through a fascial needle in the same manner as a strip cut from the thigh.

The advantages of such an expedient are apparent. The operation is shortened, no second incision is required, a local anæsthetic is quite adequate for the whole procedure, and the first anchoring stitch is avoided as the strips are already attached to bone. On the other hand, the fascial material is almost necessarily limited to two strips, and in a large hernia these may be of poor quality. The length of the strips will rarely exceed seven inches, and while it is quite possible with two such sutures to carry out Gallie's double reinforcement of the posterior wall, it is difficult to reinforce the internal ring with a two-fold girdle of fascia in the manner he recommends. The method is therefore eminently suitable for defects of moderate size requiring reconstruction, but inadequate for the major problems of inguinal repair.

The details of this operation, which resembles Gallie's in all essentials, can be understood by reference to the preceding section.

(4) *The Wyllys Andrews imbrication operation.*

This operation, published as long ago as 1895, has maintained its place as a soundly planned method of reconstruction of the posterior wall of the inguinal canal, which is eminently suitable for those cases where the tissues are sufficiently good to permit the firm imbrication of aponeurotic tissues, upon which its success depends. (Andrews, *Surg. Clinics of N. America*, 1934, XIV, 919.)

The skin incision and the exposure of the external oblique aponeurosis are made in the usual manner, except that the pillars of the external ring must be defined with particular care, and the subcutaneous tissues must be cleared from the aponeurotic layers a full inch below

Poupart's ligament. The incision in the external oblique is also made as in the standard operation, but must be so placed that the lower aponeurotic flap is sufficiently wide to cover the cord at the end of the operation—that is, it must lie at least 3 to 4 cms. above Poupart's ligament. When the aponeurotic flaps have been reflected the cremaster is incised, the cord lifted from its bed, and the hernial sac dissected out and ligatured in the usual manner. The essential part of this operation is that the inguinal canal is reconstructed by forming a strong fibro-muscular posterior wall behind the cord, consisting of conjoined tendon, cremaster and upper leaf of the external oblique aponeurosis. This flap is brought down to Poupart's ligament, in the original Wyllys

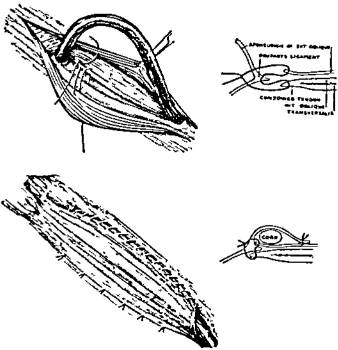


Fig. 2009.—Wyllys Andrews' operation.

(*Top*) Details of the "W" stitch which draws the conjoined tendon and upper leaf of the external oblique aponeurosis down to Poupart's ligament behind the cord

(*Bottom*) Suture of the lower leaf of the external oblique aponeurosis in front of the cord.

Andrews technique, by a small number of very stout mattress sutures of stout kangaroo tendon placed about 2 cms. apart (fig. 2009, top). There does not appear to be any particular virtue in the coarseness of the material or in the wide spacing of the stitches, and I have used sutures of No. 1 chromicised catgut with perfectly satisfactory results. The manner of inserting the stitches is, however, important. Each is passed, first from the deep fascia of the thigh below Poupart's ligament into the inguinal canal, while a finger guards the femoral vein from injury; then through the conjoined tendon and cremaster from within outwards, taking a generous bite of their substance; then back through the recurved edge of Poupart's ligament; then through the upper leaf

of the external oblique aponeurosis some distance from its edge; lastly, back through the lower leaf of external oblique very close to Poupart's ligament, to appear on the thigh close to its point of first insertion. This "W" stitch, which appears complicated in verbal description, will readily be understood by reference to figure 2009. The effect when the stitch is tied on the outer surface of the aponeurosis is to bring the upper aponeurotic flap and the conjoined muscular sheet down above and below the edge of Poupart's ligament, which projects between them (fig. 2009, inset). The first stitch should be right at the medial end of the canal, and should pass through Gimbernat's ligament; the last should be just medial to the point of emergence of the cord from the internal ring. Each stitch, as it is inserted, should be caught in artery forceps, and none should be tied till all are in place; if this precaution is neglected it may be difficult to secure the conjoined tendon with the later ones.

When all the stitches are tied, a firm posterior wall will have been constructed behind the cord. The cord is laid back on this bed just above Poupart's ligament, and the lower leaf of the external oblique aponeurosis is then sutured over it to make a roof for the canal (fig. 2009, bottom). Suture is started at the lateral end of the canal, and continued inwards till the external ring is reduced to the size of the tip of the little finger.

The essential requisite for Wyllys Andrews' operation is a good external oblique aponeurosis. In many cases where it would be most applicable, this layer is so stretched and thinned by an old-standing hernia and the pressure of a truss, that it is of little value as repair material.

Girard described a similar operation to that of Wyllys Andrews in 1898.

(5) *Other methods of posterior repair.*

(*a*) *Bassini's operation.* The skin is divided in the line of the inguinal canal, and the external oblique is exposed and incised from the external ring to a short distance above the internal one. The cord bundle is freed from cremasteric fibres, and the hernial sac isolated from the other structures in the cord as far as the internal ring, ligatured, and divided. The cord is next held up, while the arching fibres of the internal oblique and conjoined tendon are united behind it to the inner shelving margin of Poupart's ligament, to make a new floor for the inguinal canal. The first stitch should pick up first a good bite of the lower fibres of the internal oblique, then the fascial margin of the inner border of the internal ring just medial to the cord, and then the curved edge of Poupart's

ligament (fig. 2010). Subsequent stitches will pass through the lower edge of the conjoined tendon and the cremasteric fibres which spring from it above, and from Poupart's ligament below. The last should take the conjoined tendon and the inguinal ligament close to their insertion. Four to six sutures in all will be required, and all should be inserted before any is tied. When the row of sutures has been tied the cord is laid back on the bed of conjoined tendon, and the external oblique aponeurosis and skin are sutured in turn.

This operation has already been criticised in the introductory section, but such criticism is directed not against the pioneer who introduced

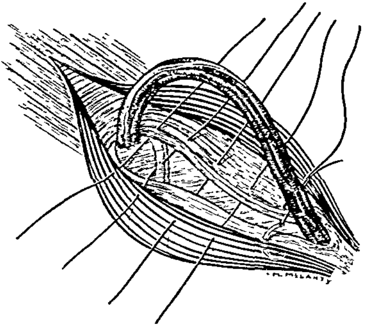


Fig. 2010.—Bassini's operation.

it, but against the men who follow him to-day. Bassini laid down the principles of free exposure of the canal and isolation of the sac up to its neck, upon which all subsequent operations are based. But the suture of conjoined muscle to Poupart's ligament, unless supplemented by something further, is useless and even harmful; useless because striated muscle forms very poor fibrous tissue, harmful in the early cases because the muscles are an essential part of the protective mechanism. That Bassini's operation in its historic form is followed by a high proportion of recurrences is familiar to any junior who sees the unselected out-patients presenting themselves to a surgical department, to any medical man who examines the employees of a large industrial concern, or to the expert adviser of truss societies. The practical experience of Gallie during the war should carry conviction. Speaking

of the large number of recurrences after the operation for hernia which were sent to him for repair he writes (*Brit. Journ. Surg.*, 1924, XII, 315): "A few which originally had been oblique hernias had recurred into the cord. In all probability the sac in these cases had never been completely removed. The majority, however, had recurred as direct hernias, irrespective of what the condition had been originally. . . . That hernias which were originally oblique should recur as direct hernias appeared to us as wanting explanation. . . . It may be that the weakening of the abdominal wall had resulted from the original operation in which the fascia transversalis may have been injured or the abdominal muscles destroyed by tight sutures. . . . In some the internal oblique muscle had been sutured to Poupart's ligament in front of the cord. In the majority, however, the internal oblique and the conjoined tendon had been sewn to Poupart's ligament behind the cord in an attempt to restore the obliquity of the canal. . . . In every recurred hernia operated upon, the internal oblique muscle had separated from Poupart's ligament throughout its inner half, and in some there was no evidence whatever that it had been sewn to the ligament. In not one instance, despite the fact that the records showed that the conjoined tendon and the sheath of the rectus had been sewn to Poupart's ligament with kangaroo tendon or catgut, did we find these structures together at the time of the second operation."

Bassini's operation stands in the same relation to hernia surgery that the carbolic spray does to aseptic technique: it should be kept in the same honoured place—the museum.

(*b*) *Bloodgood's rectus sheath flap.* The device of turning outwards a semilunar flap from the anterior sheath of the rectus to reinforce the inguinal canal has been advised and practised by many surgeons. It is most commonly referred to as Bloodgood's contribution to the elaborated and perfected form of Halsted's anterior method of repair which is often termed the Johns Hopkins operation. (W. S. Halsted, *Johns Hopkins Hosp. Bull.*, 1903, XIV, 208.) The rectus sheath flap is, however, not necessarily associated with anterior repair, and is used by many surgeons to reinforce the muscular sheets in a posterior reconstruction operation, much as the upper leaf of the external oblique is used in the Wyllys Andrews method. The diagram (fig. 2011) explains the method of cutting and suturing the flap.

While this method undoubtedly provides a strong aponeurotic flap, it leaves at the same time an unguarded area at the outer border of the rectus muscle, an area which is only protected by a thin sheet of transversalis fascia, and which is made wider by the suture of the

flap to Poupart's ligament. The likelihood of a direct hernia is therefore a real one.

Several surgeons (Downs, Schley, Blake) have advocated lateral displacement and suture to Poupart's ligament of the rectus muscle itself. Modern opinion tends to the view that striated muscle is a first-class ally when allowed to do its own job; displaced, transplanted, or pulled upon by stitches it is thoroughly unreliable. Gallie's remarks upon the late results of internal oblique suture apply with even more force to the operation of rectus displacement.

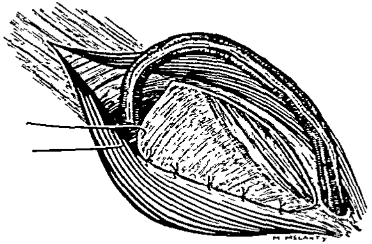


Fig. 2011.—POSTERIOR RECONSTRUCTION OF THE INGUINAL CANAL. BLOODGOOD'S RECTUS SHEATH FLAP.

(*c*) *Schmieden's operation.* Schmieden of Frankfurt has recently published a new method of posterior repair which, while it has not yet been widely tested, appears to be worthy of trial. After isolation and ligature of the sac in the usual manner, he pulls upon the cord and dissects the testis entirely free from the scrotum. The internal oblique and transversalis muscles are then split in the line of their fibres by blunt dissection about one inch above the internal ring (fig. 2012). The testis is drawn through this aperture, which is then narrowed by one or two catgut stitches to the exact size of the cord. The inguinal canal proper is completely obliterated by suture of the conjoined muscles to Poupart's ligament throughout their length. The testis is replaced in the scrotum, and the external oblique repaired over the cord.

Schmieden's operation is clearly an elaboration of Bassini's. It has two apparent advantages: first, that the cord, instead of passing from the inner margin of a stretched ring through muscles already weakened, but brought together by suture, now runs outwards from the peripheral part of the ring through a fresh incision in healthy muscles; and second, that the new inguinal canal is longer and more oblique than that which it replaces. In criticism it must be pointed out that

the inherent defects of the Bassini operation still apply to the closure of an empty canal, and that complete dislocation of the testicle may bring in its train sequelæ such as atrophy or hydrocele.

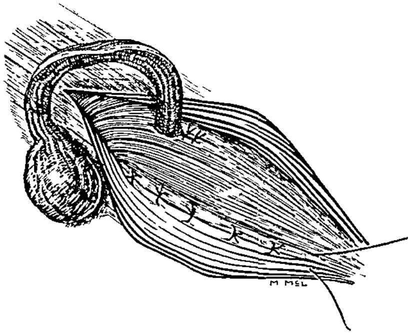


Fig 2012.—Schmieden's operation.

(6) *The anterior methods of repair.*

(*a*) *Halsted's operation.* The skin and external oblique aponeurosis are incised over the inguinal canal, and the external oblique flaps are dissected back to show clearly the cremaster and conjoined tendon. The cremaster is incised longitudinally a little above the centre of the cord. The hernial sac is then identified, separated by dissection from the structures of the cord right up to the internal ring, transfixed, ligatured, and cut across. During this step the other constituents of the cord, and particularly the vas, are left on the posterior wall of the canal, and indeed disturbed as little as possible. The muscular layers are then imbricated over the cord in the following manner: The lower flap of cremaster is first drawn up under the internal oblique and conjoined tendon by a series of mattress sutures of fine catgut passed through its free edge and then through the internal oblique muscle about an inch above its lower border (fig. 2013, top); the conjoined tendon is then sutured to Poupart's ligament by a series of interrupted stitches (fig. 2013, bottom). The operation is sometimes modified by incising the rectus sheath vertically to allow the conjoined tendon to be brought down to Poupart's ligament with less tension, or by turning a flap of anterior rectus sheath over the conjoined tendon. The operation

is completed by suturing the flaps of the external oblique aponeurosis with a similar overlap to the muscular layers, the lower leaf being drawn under the upper one (fig. 2014).

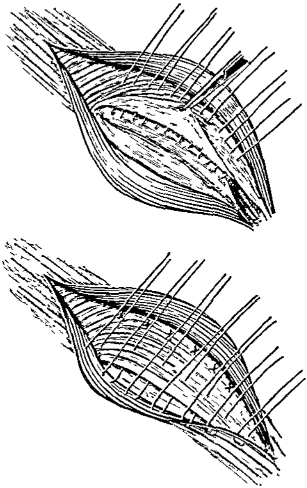


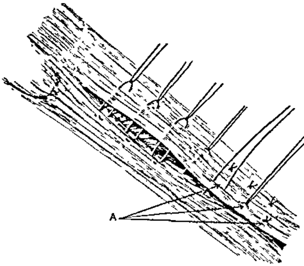
Fig 2013.—Halsted's operation.
(*Top*) Suture of cremaster to deep surface of conjoined tendon in front of cord.
(*Bottom*) Suture of conjoined tendon to Poupart's ligament.

(*b*) *Ferguson's operation.* This operation is similar in its essentials to the Halsted operation, but, being based upon the author's belief that the chief cause of hernia is a deficiency of the internal oblique and transversalis muscles at their origin from Poupart's ligament, it concerns itself particularly with the outer half of the canal. The preliminary steps up to the exposure of the cord differ little from those of any other operation, except that Ferguson advised splitting the fibres of the external oblique up to a point opposite to the anterior superior iliac spine, in order to ensure a complete view of the deeper layers. The sac is dissected out and removed without disturbing the cord as in the Halsted operation. The internal ring is narrowed by the insertion of two or three catgut stitches through transversalis fascia anterior to the cord. The internal oblique and transversalis muscles are then stitched

to the recurved edge of Poupart's ligament, the sutures starting at the outer end and extending no more than two-thirds of the way towards the pubic spine, unless the hernia has been a particularly large one. The operation is finished by closing the external oblique aponeurosis with overlap, as in the Halsted operation.

I have already expressed my personal disagreement with the principle of anterior repair. I would repeat these sentiments by quoting Gallie once again, that " the time which is spent in preventing a hernia from getting out of the canal is much better spent in preventing it from getting into it." Both Halsted's and Ferguson's operations, by leaving the cord undisturbed, ignore the factor of medialward shift of the internal ring which is so potent a factor in recurrence.

Fig 2014.—HALSTED'S OPERATION. IMBRICATION OF THE EXTERNAL OBLIQUE APONEUROSIS. THE LOWER LEAF HAS BEEN DRAWN UNDER THE UPPER BY A SERIES OF SUTURES, THE INNER THREE OF WHICH ARE TIED AND CUT. (A) INDICATES THE FIRST THREE SUTURES OF THE SECOND LAYER WHICH ATTACHES THE UPPER LEAF TO THE NEIGHBOURHOOD OF POUPART'S LIGAMENT.



Ferguson's operation, indeed, by repairing the ring anterior to the cord, a repair that can only be done in its outer half, aggravates the shift still further. There is, so far as I know, no anatomical or clinical evidence whatever to support Ferguson's view that the origin of the deeper muscles from Poupart's ligament is deficient in hernia cases. During a clinical career extending over twenty-six years I have either opened or seen opened between 3000 and 4000 inguinal canals, but I have yet to see such an abnormality.

IV. SPECIAL PROBLEMS CONNECTED WITH INGUINAL HERNIA

(1) *Unusual difficulties encountered in the operation for Oblique Inguinal Hernia.*

(*a*) *The really large hernia.* An oblique hernia may, if neglected, attain truly massive proportions. Every surgeon has from time to time encountered such swellings, which vary in size from that of a grape-fruit to a Rugby football or even larger, and may extend as far

some of the contents will have returned to the abdomen, and the patient's general resistance will be improved.

Secondly, the great bulk of these large herniæ is usually made up of omentum, which has increased in size during its residence in the sac, and only a small part of it is intestine. The omentum can be ligatured at the neck of the sac and cut away, leaving a relatively small bulk of intestine to be returned to the abdomen.

Thirdly, local anæsthesia is entirely satisfactory and almost entirely safe for such operations; in the type of subject under discussion, it is usually to be preferred.

Fourthly, the operation may be heroic, but it can be interrupted at any time, and should be if the condition of the patient gives rise to anxiety. I have on occasion done these large hernia operations in three stages, all under local anæsthesia, a week or ten days intervening between each: First, exposure of the sac, and ligature and excision of omentum; second, freeing from adhesions and return to abdomen of loops of intestine, followed by closure of the neck of the sac by a simple purse-string suture; third, proper isolation and ligature of neck, removal of remainder of sac, and closure of hernial canal.

The operation will follow the general lines of the standard one with such modifications as are imposed by the size of the swelling and the condition of the skin (a wide ellipse may be required to excise an ulcerated area). When the cremasteric layer, here consisting of fat and fibrous tissue, has been reflected off the cord, the sac should be opened immediately and its contents dealt with from inside; only when it has been emptied and closed at the internal ring should any attempt be made to separate it from the cord. When the sac has been excised, it is rarely practicable, in my experience, to attempt radical cure. The external oblique aponeurosis is like tissue-paper, Poupart's ligament runs along the lowest part of the deficiency as a narrow strip which

as the knees of the patient. The skin over them is thinned, eczematous or even ulcerated, and the penis is entirely buried by the swelling, so that the urine dribbles through a small depressed orifice, excoriating the surrounding area. The patient, unable to take any exercise, is fat, emphysematous, and constipated, and usually shows in addition the signs of myocardial degeneration.

Such men present a heartbreaking surgical problem, but the majority have no desire for operation, and present no urgent symptoms rendering it necessary. Considering the technical difficulties and the risks of such a step, this is indeed fortunate. Some can be made comfortable and allowed a certain amount of activity with a bag truss; many are necessarily bedridden.

Occasionally, however, the surgeon is urgently requested to undertake operation in such a case, or may feel obliged to advise it himself. The patient may be younger than usual, and some stimulus, a new sweetheart, the prospect of a job, or even the desire to cease dependence upon others, impels him to demand a chance of leading a more active life. Recurring attacks of partial intestinal obstruction may force the surgeon's hand.

The technical difficulties in such a case are that the operation itself is one of considerable magnitude. that all structures are so distorted and interlaid with fat that the usual landmarks are barely recognisable, that when the contents of the sac have been freed there is often insufficient room in the abdominal cavity to allow their reduction, and that, even supposing the contents have been reduced and the hernial sac tied off, the structures of the inguinal region have been so distorted and atrophied by pressure, that any form of satisfactory repair is impossible. The risks are even more apparent—those of a really severe and lengthy operation on a patient whose cardiac, renal and respiratory systems are only just adequate for a quiet existence.

The surgeon faced with such a problem may reflect whether his difficulties cannot be lessened by attention to some of the following points:

Firstly, in any such case, the greater part of the coverings of the swelling. of the contents of the sac, and of the structures in the abdomen into which those contents must be returned, consists of fat. If the patient is kept in bed with the foot of the bed raised on blocks 14 inches high for six weeks before operation, purged regularly, and placed on a really strict reducing diet, not only will the size of the swelling to be tackled be reduced about 50 per cent, but

some of the contents will have returned to the abdomen, and the patient's general resistance will be improved.

Secondly, the great bulk of these large herniæ is usually made up of omentum, which has increased in size during its residence in the sac, and only a small part of it is intestine. The omentum can be ligatured at the neck of the sac and cut away, leaving a relatively small bulk of intestine to be returned to the abdomen.

Thirdly, local anæsthesia is entirely satisfactory and almost entirely safe for such operations; in the type of subject under discussion, it is usually to be preferred.

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allow the patient a degree of activity which, compared with his former state, means a new lease of life.

(*b*) *Sliding hernia.* The term "sliding hernia" indicates one in which increasing size has dragged down the adjacent parietal peritoneum into the hernial canal, and with it some neighbouring organ normally situated behind it. The hernial swelling therefore consists in part of a serous sac with the usual contents—omentum, or omentum and bowel—and in part of an organ which lies in the hernial canal beside the sac, that is, covered by its peritoneum on one aspect only. For practical purposes the organs found in a sliding hernia are either large intestine, the cæcum on the right and iliac colon on the left, or the bladder. The conditions under which these two organs are encountered in hernia surgery are so different that I propose to treat each separately.

The large intestine is usually encountered in the para-peritoneal situation in large, old-standing, oblique herniæ, very rarely in direct ones, and more commonly on the right side than the left. The condition is rarely recognisable with certainty on clinical examination; the swelling will not be completely reducible, but usually all that the surgeon is able to decide before operation is that the hernia is a large one of the type in which complete reconstruction of the inguinal canal will almost certainly be required. Even at operation the true state of things may not be immediately apparent. The sac when first picked up after reflection of the cremaster presents no unusual appearances except that it cannot be rendered empty, and the stripping of vessels at first proceeds according to plan; a point is reached, however, when it becomes apparent that the tissue under the left thumb is plain muscle and not peritoneum, and that the vessels which lie along it are not those of the cord, but the posterior cæcal vessels in the wall of the bowel. A surgeon encountering such a hernia at his first operation is almost bound for disaster; he will proceed with the methodical blunt dissection till he has either torn a hole in the cæcum or is brought to a standstill by furious bleeding from the cæcal vessels. One who has served his apprenticeship under supervision will be familiar by repeated handling of the usual herniæ with the feel and the white appearance of the normal sac, and the parallel arrangement and characteristic blanching and filling of the spermatic vessels as they are peeled off it. If he meets anything unusual—bowel which is slack yet will not reduce, peritoneum merging into a surface that is clearly plain muscle, or vessels that tear rather than separate—he will at once open the sac at some point where its wall is clearly not adherent, and see what he is dealing with. A sac should in any case be emptied, if possible before it is separated

from the cord; should this be impossible (the usual cause is adherent omentum), and provided that the surgeon is satisfied that omentum only lies in the sac, he may proceed to isolate it. In the case of any large oblique hernia apparently containing bowel which cannot be reduced, he should proceed with the greatest care, and in most cases open the sac first.

The bladder is not infrequently found as part of the wall of a direct inguinal hernia, but it may also come to lie as a relation of the inner side of the neck of a large, old-standing oblique one. The presence of the bladder in a hernia is often recognised upon clinical grounds by the history of double micturition. The patient discovers that after emptying his bladder he can produce a further flow of urine by some change of position, or by pressing on the hernia. If the surgeon follows the rule that the sac of a direct hernia should not be opened, and that that of an oblique one should be isolated, firstly half-way down the inguinal canal, then at the fundus, and lastly at the neck, he need have little fear of injuring the bladder. He will be warned by a sudden thickening of the neck of the sac at its inner side, and by the appearance of scattered muscle bundles and large veins, and will explore the bladder region by a finger in the neck of the sac.

Should the cæcum or bladder be wounded, the rent must be repaired at once with a double row of sutures. After a cæcal tear, the whole canal should be swabbed out with $\frac{1}{1000}$ flavine solution, and a corrugated rubber drain left in the wound for forty-eight hours; after a tear of the bladder, a catheter should be tied in.

The sac of a sliding hernia can only be removed where it is free from the extruded viscus—that is, in its more distal portions. Such redundant peritoneum should be cut away freely with scissors, the opening closed with a purse-string suture or a running stitch, and the remainder pushed back into the abdomen with the attached colon or bladder. In an old-standing hernia patient dissection may be necessary in the neighbourhood of the internal ring, to allow the whole swelling to be returned to the abdomen. The posterior wall of the canal must then be repaired over the weakened area by one of the methods of reconstruction described previously. Some writers advise that repair of a sliding hernia should be followed by some form of colopexy. The surgeon who believes that these pexy operations serve any useful purpose may be tempted to follow this advice.

The account of sliding hernia given above has necessarily dealt with a very large and important aspect of hernial surgery in a simplified way, and from an extremely practical outlook. The reader who wishes

to pursue the subject further will find it discussed in great detail in L. F. Watson's book *Hernia*, Chapters XXIII to XXVII (London, Henry Kimpton, 1924).

(*c*) *Interstitial hernia.* An interstitial hernia is an oblique hernia in which the disposition of the peritoneal sac departs from the normal course of the cord and funicular process. The whole sac may be so displaced; more often the abnormality is an aberrant diverticulum from a sac which lies in the fascial sheath of the cord, the two communicating with the abdominal cavity by a common opening. An interstitial hernia is usually an accompaniment of late or imperfect descent of the testicle; but it may also be acquired, the result of abdominal pressure distending the proximal part of a sac whose distal portion is blocked by adhesions or the pressure of a truss. Three varieties are described:

(1) *The Properitoneal*, where the sac extends within the abdominal wall between the peritoneum and transversalis fascia. The properitoneal sac may pass inwards towards the bladder and pubis, or outwards parallel to Poupart's ligament.

(2) *The Intra-muscular*, lying between the external oblique aponeurosis and the internal oblique muscle; such a hernia may extend laterally, parallel to Poupart's ligament, or directly upwards.

(3) *The Superficial*, in which the sac, after leaving the external ring, turns back over the abdominal wall instead of reaching into the scrotum.

Of the three varieties, the first rarely gives rise to any symptoms or physical signs whereby it can be recognised. The second and third present swellings with the main characters of an inguinal hernia, but lying in an unusual site. The intra-muscular hernia can usually be diagnosed by the manner in which its outline becomes obscured when the external oblique muscle is put into action. The superficial type is occasionally mistaken for a femoral hernia.

Except in strangulation, when the concealment of an obstructed loop in such a diverticulum may cause some confusion at operation, these interstitial herniæ are of little more than academic interest. The surgeon who dissects the inguinal canal layer by layer will have no difficulty in recognising such abnormalities, even should he not suspect them beforehand, or in dealing with them when he meets them.

(*d*) *Recurrent hernia.* The operative treatment of a recurrent inguinal hernia differs from that of a primary one only in the added

difficulty in establishing the planes and exposing the defect which is inevitable where a previous operation has been performed. The guiding principle of all repair surgery—to expose structures where they are normal—governs the method of approach.

The cutaneous scar of the previous incision is first outlined with an elliptic cut, and this cut is deepened through the fat above and below the operation area till the aponeurotic layer is exposed. When this layer has been defined all round, the ellipse of fat and skin is cut away with a sweep of the knife. A little trimming with knife or scissors will then define the old suture line in the external oblique. The aponeurosis is next slit with a knife in the line of the old incision, but just above its upper end, in order to open the subaponeurotic layer where it is unscarred. The closed Mayo scissors are pushed into this slit and worked down between the aponeurotic and muscular layers till the ring is reached ; when the plane has thus been freed, the slit is extended down through the old scar into the external ring, and the flaps are turned up and down.

The nature of the subsequent steps will depend entirely upon the condition which is now disclosed, and the decision of the surgeon will be based upon the same principles which guide him in operating upon a primary hernia. In a surprising number of cases there is an almost virginal inguinal canal, containing a complete congenital sac ; it is clear that the previous operator has either missed his bearings, as may easily happen if the repair was done during infancy, or has been forced by some anæsthetic difficulty to abandon the operation uncompleted. In the majority, however, the hernia has recurred as a direct one, and some form of plastic reconstruction is required.

(2) *The localised form of Direct Hernia.*

This type of hernia, which is admittedly a rarity, and which I have not found described in any of the works I have consulted, is referred to on page 3620 ; I have met perhaps half a dozen instances. The hernial opening is medial to the deep epigastric artery, but is not a giving way of the whole region, but a circumscribed aperture with sharp margins in a firm posterior wall. The sac is tubular and emerges through the external ring beside the cord. The hernia is therefore believed to be oblique and an operation is undertaken on this diagnosis; only when the cremaster has been reflected does its nature become clear. Whatever the origin of the defect, its repair is an extremely simple matter, requiring no more than excision of the sac and approximation of the margins of the opening, either by silk or by a simple pedicled aponeurotic strip cut from the upper leaf of the external oblique.

(3) *Methods of approach to Inguinal Hernia other than through the Inguinal Canal.*

(*a*) *Through the abdominal cavity.* Both Annandale and Lawson Tait formerly practised an approach to the inguinal canal by a mid-line laparotomy incision. More recently G. P. La Roque (*Surg., Gyn. and Obst.*, 1919, XXIX, 507) advised opening the peritoneal cavity well above the internal ring by splitting the internal oblique and transversalis muscles about an inch above their lower margin, after exposing the sac in the inguinal canal. He inverts the sac into the upper incision and sutures across the peritoneum well above its neck, passing these sutures also through the new opening. It is difficult to see any real gain in either method. Plastic operations upon the peritoneum will avail little if the fibrous or muscular defences of the canal have given way, and inversion of the sac may damage the internal ring.

(*b*) *The extra-peritoneal approach.* Lenthal Cheatle (*B.M.J.*, 1921, II, 1025), and more recently Professor A. K. Henry (*Lancet*, 1936, I, 532), have advocated approach to the inguinal canal by the extra-peritoneal route, through a mid-line incision. By pushing the peritoneum back from the transversalis fascia, the back of the inguinal canal and the internal ring is reached with extraordinary ease and rapidity. Removal of the sac from the inguinal canal is obviously a much more intricate problem, and the surgeon who is familiar with the prolonged and careful dissection which is required to separate sac from cord in the usual operation, may feel alarmed at the prospect of this "blind extraction." Both surgeons admit the difficulty: Cheatle advises that when separation is not easy, the sac should be divided and its distal part left in the canal, while Henry states that the dissection is made comparatively simple if an assistant keeps the cord taut by holding down the testis in the scrotum.

Whether the extra-peritoneal method will prove of real value in the surgery of inguinal hernia cannot be decided till it has had a more extended trial. Henry has probably contributed more advances of real importance to technical surgery, in the way of new routes of approach planned upon anatomical lines, than any other surgeon in active practice to-day. His recommendation alone should ensure the method a trial, and his claim that the internal ring and posterior wall may be repaired more readily from within than without, is, on the face of it, a reasonable one.

CHAPTER III

Femoral Hernia

A review of the accepted teaching of anatomical text-books is even less necessary in this section than in that devoted to inguinal hernia. There would be no femoral hernia problem were the lower limb fixed, like the upper, entirely to the outer framework of the trunk. Unfortunately the whole group of the flexor muscles of the thigh extends well into the abdomen, indeed above it into the thorax. The abdominal musculature is everywhere firmly anchored to the bony and ligamentous boundaries of the cavity, except where this troublesome group of muscles must be allowed exit. The shallow trough in which they run is bridged by Poupart's ligament, which is anchored to its two margins, the anterior superior spine of the ilium and the spine of the pubis. The anchorage at the inner end is continued by Gimbernat's ligament which, separately named, can only be viewed as the deeper part of Poupart's ligament, fanned out for more secure attachment. Gimbernat's ligament, then, fills up the outer angle of the flexor trough; it is roughly an equilateral triangle, whose apex is at the pubic spine, one of whose margins is continuous with Poupart's ligament, another attached from the pubic spine along the inner end of the ilio-pectineal line, the third free and facing outwards towards the sub-Poupart trough. On the ilio-pectineal line, Gimbernat's ligament is sandwiched between two other structures of surgical importance (fig. 2015), the origin of pectineus below (an origin which is linear and tendinous and not wide as illustrated in books on osteology; the tendon of origin is known as Astley Cooper's ligament) and the insertion of the conjoined tendon on its pelvic side.

Poupart's ligament is secure enough above—it is part of the abdominal musculature; below, its security appears to depend on faith and fibrous tissue (fig. 2016). The fascia lining the abdomen, transversalis fascia in front and iliac fascia behind, sweeps round in a continuous sheet, gaining attachment to Poupart's ligament as it passes behind it; the same fascia is, however, continued into the thigh as the sheath of the iliacus and psoas, so that Poupart's ligament is fixed to these muscles where they pass under it by connective tissue

bands. Nerves and muscles pass into the thigh. The nerves, arising from the vertebral canal, are always behind the fascia ; but the vessels, coming from trunks which lie on the vertebral bodies in front of the posterior muscles, are in front of their fascia, and hence, reaching a point where this fascia sweeps up behind Poupart's ligament to reach the anterior wall, they must push through it, carrying a fascial coat on their walls. This coat is the femoral sheath.

In the thigh the fascia iliaca becomes the deep fascia covering the flexor group of muscles to the outer side of the femoral vessels. A new fascial layer, that over the pectineus, appears in the thigh behind the vessels, and this sheath, known here as the pubic fascia, is attached to

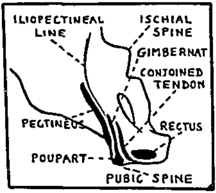

Fig 2015.—Diagram, modified from Frazer's *Anatomy of the Human Skeleton*, to show attachments to the ilio-pectineal line.

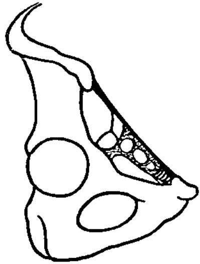

Fig. 2016.—The fascial attachments of Poupart's ligament.

the femoral sheath in front, and through that to Poupart's ligament, and behind dips down in the interval between the pectineus and psoas to become firmly fixed to the ilio-pectineal eminence and the capsule of the hip-joint. This band, the connective tissue web extending back from Poupart's ligament, embracing the femoral vessels, and anchored behind to the framework of the pelvis, is the only one stout enough to be demonstrable by ordinary methods of dissection.

The two fascial layers in the thigh, the iliac laterally and the pubic medially, blend below the point where the saphenous joins the common femoral vein. Above this point the iliac fascia stops short in a sharp border which bounds the saphenous opening laterally, and then sweeps above it as the falciform or Hey's ligament, to join the inner end of Poupart's ligament, and through it Gimbernat's ligament;

the pubic fascia has no real margin but passes behind the vessels as has been described. The saphenous opening is bridged by a thin sheath —the cribriform fascia. A sketch of the sub-Poupart trough, and one of the attachments to the ilio-pectineal line is appended (figs. 2015 and 2016).

When these somewhat indefinite moorings of Poupart's ligament are considered, it might be expected that the abdominal contents would force their way under it into the thigh at almost any point, if propelled by repeated pressure. Such is actually the case; herniæ are seen outside, behind, and in front of the femoral vessels, and even through Gimbernat's ligament and between the pectineus and its fascia. All these are, however, rarities, seldom encountered in the ordinary surgical lifetime. A sub-Poupart hernia is nearly always through the crural canal—that is, a femoral hernia.

The crural canal is described as the innermost of three compartments of the femoral sheath—the arterial, the venous, and the crural canal. Its walls are the same fascial layers. Above, it has an opening bounded by Gimbernat's ligament medially, Poupart's ligament in front, the origin of pectineus behind, and the femoral vein laterally; the opening is sealed from the peritoneum by a fibrous sheet, the septum crurale. Below, its walls converge to join the femoral sheath. The contents of the canal are said to be fat, a lymph gland, and lymph channels running from the deep femoral to the external iliac group of glands. Thus far is orthodox teaching; but the conscientious demonstrator in the dissecting-room who is asked by the student to show him the crural canal is torn between his desire to support authority and the faith of the young, and his inability to produce anything convincing. It is more rational to regard this channel, with Keith, as a hypothetical space and a dissecting-room product—in reality the inner half of the venous compartment. The circulation of the thigh during activity may be increased anything from ten to twenty times, and to carry this augmented flow of blood the femoral vein must have room in the rigid sub-Poupart trough to increase its cross-section. Under such conditions it is probable that there is no crural canal; after death there is no circulation and the crural canal appears.

These anatomical and functional considerations have a very definite bearing upon the surgery of femoral hernia; if accepted, they necessarily imply certain conclusions which must govern the principles upon which operations are designed:

1. That the hernial opening begins, and the neck of the peritoneal sac lies, at the inner edge of Gimbernat's ligament. This level is well

above Poupart's ligament and still more remote from the saphenous opening. The sac cannot, therefore, be controlled up to its neck by any form of truss, nor can its junction with the parietal peritoneum be reached by any approach from below, except after an amount of traction and forcible separation of fibrous planes which is more likely to invite recurrence than is high ligation to prevent it. For the same reason the crural opening cannot be closed securely and safely at its commencement by any method of suture from the thigh.

2. That Poupart's ligament depends for its security less upon demonstrable bonds than upon a wide fascial anchorage. Any avoidable damage to these fibrous planes, such, for instance, as that caused by dragging a femoral sac from the thigh to the abdomen through the crural canal, will, on the face of it, induce a weakness for which subsequent repair may not adequately atone.

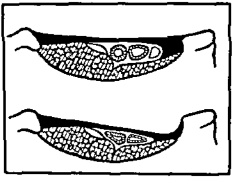

Fig 2017.—To illustrate the effect of suturing Poupart's ligament to the ilio-pectineal line, or pegging it to the bone.

3. That the crural canal is a sub-compartment of the venous channel, and Poupart's ligament is the selvedge of the anterior abdominal muscular sheet. Any method of closing the hernial channel which depends upon fixing down Poupart's ligament is unsound on both counts, because it must compress the vascular tunnel in an antero-posterior direction, and because the fixation must in time yield to the continual play of the abdominal muscles (fig. 2017).

THE ÆTIOLOGY OF FEMORAL HERNIA

Hamilton Russell, whose exposition of the congenital nature of oblique inguinal hernia has formed the basis of contemporary teaching, has endeavoured to apply the same theory to the formation of femoral hernia. (*Lancet*, 1906, II, 1197; *Brit. Journ. Surg.*, 1923, XI, 148; and *Surg., Gyn., Obst.*, 1926, XLIII, 147.) His view is that, with the growth of the limb bud during embryonic life, the vessels to the lower limb are drawn downwards from the abdominal cavity, and in some instances draw with them a pouch of peritoneum. In support of this hypothesis he states that the common directions in which a femoral sac extends after leaving the saphenous opening correspond to those of the main branches of the artery. The lingering of the congenital theory of femoral hernia to the present day is a tribute to Mr. Russell's eminence

as a surgeon, to his pioneer work in inguinal hernia, and to his persistent enthusiasm. No support whatsoever has been forthcoming from embryological research, from dissections of the fœtus, or from operation on the new-born child. A peritoneal pouch has never been seen in the limb bud, nor was Sir Arthur Keith (*Brit. Journ. Surg.*, 1924, XI, 455) able to find a femoral sac in five hundred human fœtuses examined. Russell counters this by saying that a number of sacs are found post mortem in adult bodies where hernia was unsuspected, and asseverates that from birth to adult life the vessels to the lower limb are "making a slow progress downwards," and are therefore liable to drag down peritoneum with them. The first argument can be applied to anything; if we find gall-stones or duodenal ulcers in people who have never had pain, does it mean that these lesions are congenital? The second suggestion is astounding; if we are to believe that the femoral artery increases in length by being pulled progressively out of the abdomen as a worm is pulled out of a hole in the lawn, and not, as do all other structures in the limb, by multicentric growth, we must also believe that all its lateral branches are simultaneously creeping up to the abdomen along its walls, or we should find them in the adult pointing towards the head like the bristles on an ear of barley. Why, also, should the sac always lie to the inner side of the vein, and never accompany the artery? To the best of my belief the majority of surgeons in Britain and on the Continent accept femoral hernia as perhaps the most typical example of an acquired defect, and find no foundation for the congenital theory.

Such a summary may be too sweeping. Femoral hernia is occasionally encountered in childhood, where the factors causing an acquired yielding would seem to be lacking; but it is sufficiently rare (two in three hundred in my own experience), and almost unknown under the age of ten. Two causes appear to be operative—repeated strain, and the development of fat which presumably weakens the fibrous planes of the femoral region.

Femoral hernia is less common than inguinal, but whereas in men the proportion is about one femoral hernia to twenty inguinal, in women it is about one to three. Comparing the sexes, femoral hernia is about six times as common in women as in men, but this disproportion is almost entirely accounted for by its prevalence in women who have borne children; the incidence in those who are childless is about the same as it is in men. Femoral hernia is then very largely a labour casualty, and the conditions under which civilised women bear their children, involving as they do a femoral vein emptied by rest and the

recumbent position, and abdominal contractions more prolonged and severe than are ever seen in savages or animals, seem ideal for its production.

PATHOLOGICAL ANATOMY AND DIFFERENTIAL DIAGNOSIS

The coverings of a femoral hernia, beyond the skin and superficial fascial layers, should be cribriform fascia, fat in the saphenous opening, femoral sheath, fat in the sheath, septum crurale, extra-peritoneal fat and peritoneum—that is, alternate layers of fat and fascia. Needless to say, these layers can never be demonstrated, but it is notorious that many, a most puzzling number, will be divided in turn before the actual sac is reached. The operator would be wise to remember the aphorism that "a femoral hernia has as many layers as an onion." In any case, the coverings form a bulky mass, usually exceeding considerably the sac in their midst; this bulk accounts for the well-known fact that, while the contents of a femoral hernia may be reducible, a palpable lump nearly always remains in the saphenous opening after reduction.

The size of the sac and its coverings varies greatly, and tends to increase with the duration of the hernia; the neck, however, lying in a rigid channel except for the wall of the vein on one side, tends to remain a tube of small diameter. The inguinal sac as it enlarges keeps its resemblance to a glove finger; the large femoral sac becomes a balloon on a stalk. The swelling appears at the saphenous opening, and as it enlarges tends to remain there. If it alters direction it is usually to turn upwards over the inner end of Poupart's ligament. While many fanciful reasons have been given for this line of extension, the probable explanation is that it follows the same mechanical laws *as a ribbon of tooth-paste forced through an accidental and curved* opening in the tube. A femoral hernia first comes downwards, and then forwards, because further downward expansion is blocked; each further portion as it is extruded must follow the same course, one which will push the head of the mass directly upwards.

The differential diagnosis of a femoral hernia will depend, in the main, upon whether it is reducible or not.

The majority met with in a surgical out-patient department are irreducible but quite symptomless. The sac contains nothing but omentum, which in course of time has become thickened, fibrous and adherent to the peritoneal lining; at the same time the outer coverings have increased in bulk by further deposition of fat. Such a swelling presents no symptoms, and no signs apart from those of a rounded elastic tumour in the inner half of Scarpa's triangle. It must be dis-

tinguished from an enlarged inguinal lymph gland and a lipoma—the only conditions which it really resembles. The essential point is to determine that the swelling has a neck, and that this neck passes directly backwards just below Poupart's ligament and just to the inner side of the femoral vessels. *When the lump is grasped and moved* about this can usually be demonstrated with ease. A lymphatic gland lies in the fascial plane, and is linked to other glands in that plane; it can be moved to a limited but approximately equal extent in all directions. A single enlarged inguinal gland is, in any case, unusual. A lipoma moves with the subcutaneous fat, and can be lifted off the deep fascia. A femoral hernia can only be moved in circles round its point of deep attachment—like the joy-stick of an aeroplane; in most cases the "stalk" itself can be felt.

A reducible femoral hernia may be quite clearly a hernia; that is, it reduces, not immediately, but after a little manipulation, and it returns, not immediately, but after three or four coughs. Both reduction and reappearance are accompanied by the characteristic gurgle of intestine, and the swelling, when distended, is resonant to percussion. The only difficulty in such a case arises when the sac overlies the inner end of Poupart's ligament, and the diagnosis has to be made between a femoral and an inguinal hernia. The decision will depend upon the relation of the swelling to the pubic spine, and whether, after reduction, it reappears above or below Poupart's ligament. It is often said that an inguinal hernia lies *above* the pubic spine; it usually lies *over* it. But in inguinal hernia it is only possible, by pushing from below and lateral to the swelling, to place the finger on the pubic spine, while in femoral hernia the spine can only be reached above and medial to it. After the hernia is reduced, a finger should be placed on the inner end of Poupart's ligament, and kept there while the patient coughs; it can then be determined if the swelling reappears below, that is, from the crural canal, or above, from the inguinal canal.

Two reducible swellings in Scarpa's triangle, saphena varix and psoas abscess, are often mistaken for femoral hernia; the first mistake is harmless, the second may have tragic consequences. Neither has the true characters of a hernia—that is, there is no definite rounded outline to the swelling, nothing beyond gentle pressure is required to reduce it, and nothing more than the erect position to make it prominent. Neither is resonant or gives a gurgle when handled.

Saphena varix usually imparts a bluish colour to the overlying skin. The swelling is rarely larger than a half walnut, and is so thin-walled that its outline cannot be clearly felt. It disappears not merely with

finger pressure, but when the patient lies down; when he coughs, a fluid thrill, like that in a varicocele, can be felt over it.

To suggest that a psoas abscess may be mistaken for femoral hernia may sound ludicrous; but the mistake is made repeatedly by surgeons of the highest standing, and not merely in the out-patient department, but when the patient has arrived at the operating table. It must be remembered that those who are seen with these dissecting psoas abscesses are not the text-book cases of spinal caries which are demonstrated to students, i.e. children and young adults with emaciated faces, barrel chests, and a prominent kyphos; they are old men and women in whom the disease assumes the quiet subperiosteal form, without destruction of bone, without a degree of pain suggesting anything more than "rheumatics," without even limitation of spinal movement in excess of that which accompanies osteo-arthritis. They may come to hospital for the first time to report an inguinal swelling that has appeared in the last few weeks, and give no history of backache. The wary surgeon, seeing a reducible swelling below Poupart's ligament, will be struck at once by the absence of that definition typical of a femoral sac, which usually suggests a rubber ball under the skin. A small psoas abscess, the most deceptive kind, will lie lateral to the femoral vessels; a larger one, having ruptured the psoas fascia, may be medial, but will be slack and diffuse, suggesting at once a cold abscess. Confirmation will be obtained by the demonstration of a second swelling in the iliac fossa, and the proof that material "reduced" from one merely expands the other.

OPERATIVE TREATMENT OF FEMORAL HERNIA

The operations for femoral hernia fall into two natural groups: the low operations performed through the saphenous opening, and the high operations, through the inguinal canal.

Whereas it is possible in inguinal hernia to name many of the standard operations after the surgeons who first described or popularised them, in femoral hernia such a method is valueless, for the methods have grown up rather than been introduced. The low operation is as old as surgery itself, for the first instinct of mankind is to tackle any problem in the most direct and simple manner, and only later to think of improvements; the only variations are in the methods advised to close the canal, and these merge into one another by infinitely small gradations. The high operation through the inguinal canal is usually named after Lotheissen, but even a perfunctory search of the literature shows that the inguinal approach was suggested independently by more

than thirty surgeons in different countries, of whom Annandale of Edinburgh was undoubtedly the first. In any case the Lotheissen operation, which involved dragging an unopened sac through the canal, is not, or should not be, any longer performed by surgeons, and the modern operation has many parents but no name. By the modern operation I mean the modified inguinal one, because the high approach has steadily displaced the low one since about 1920, and is now performed almost exclusively in most clinics. The low operation is, however, very much simpler, and while perhaps less well founded it is by no means unsuccessful. It is difficult to get any figures upon the recurrences which follow it, but they are certainly not more than 10 per cent, and probably more like 5 per cent. It still remains the choice of the inexperienced or unassisted surgeon who is forced to operate, it is often advisable when time-saving and minimum interference are important, and it may be the best in many cases of strangulation. In any case its first stages are those of the modified high operation.

I. The Standard Operation

(1) *The skin incision.* In my experience the crease incision (see pages 3613 and 3626) advocated for inguinal hernia is equally suitable for femoral hernia, and preferable to one placed lower. The external oblique aponeurosis and the pillars of the ring are exposed as for inguinal hernia, and the lower flap is then dissected down below Poupart's ligament off the fascia of the thigh. The femoral swelling will appear covered by a thin layer of cribriform fascia, and when this is incised with a stroke of the knife, will extrude itself as a rounded fatty mass (see fig. 2018).

(2) *Exposure, opening, and division of the hernial sac.* While the lower skin flap is retracted, the fatty mass is held up between two pairs of toothed dissecting forceps, and boldly cut across with Mayo scissors. Reference has already been made to the number and confusion of the layers which cover a femoral sac; each should be pushed back towards the neck of the swelling by strokes of the closed scissors, and *the next layer be incised only when it is clearly displayed throughout* its extent. The sac itself will be recognised without difficulty when it is reached, except in a strangulated hernia; its outer surface is more definite, whiter, and more opaque than that of any covering layer, its *inner lining is smooth and glistening*; its absurdly small size in comparison to its wrappings is the only thing that may confuse the operator. The sac, when reached, should be cleared even more thoroughly than previous layers, till its narrow stalk disappearing under Poupart's

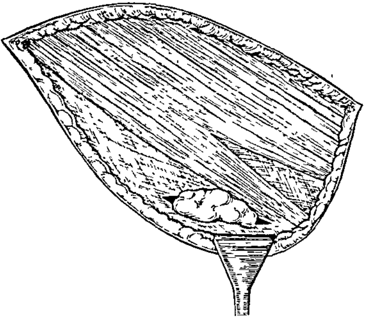

Fig. 2018.—The high (inguinal) operation for femoral hernia by the skin-crease incision. Reflection of flaps and exposure of inguinal region and hernial sac.

ligament is clearly displayed. The fundus is then opened, and any contents returned to the abdomen. Omentum, if thickened, may be ligatured and cut across; fringes of fat or loops of bowel should be returned by pressure of the tip of the finger or of a blunt instrument. Provided that the body of the sac has been emptied, any residual adhesions of omentum at the neck may be neglected at this stage. The sac is then clamped across just below its neck with a pair of hæmostats, and the remainder cut away (fig. 2019).

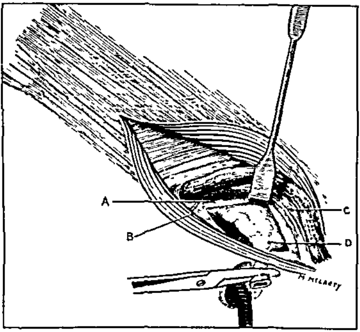

Fig. 2019.—The high (inguinal) operation for femoral hernia. The posterior wall of the inguinal canal has been incised and the neck of the hernial sac exposed from within.

A. Posterior wall of canal (transversalis fascia)
B. Poupart's ligament.
C. Conjoined tendon.
D. Neck of sac.

(3) *Opening of the inguinal canal and exposure of the neck of the sac.* The inguinal canal is laid open by an incision in the external oblique extending into the pillars of the ring, the flaps are dissected back to expose conjoined tendon above and Poupart's ligament below, the cremaster is reflected, and the cord or round ligament is lifted from its bed to expose the posterior wall of the canal. The wall is incised with a knife about ¼-inch above and parallel to Poupart's ligament, taking care to avoid the epigastric vessels medially, and their pubic branch running along Poupart's ligament. The extra-peritoneal fat exposed in this incision is then pushed upwards away from Poupart's ligament with the finger or with small pledgets of gauze held in mosquito forceps, and will separate freely till the femoral opening is reached, when it is

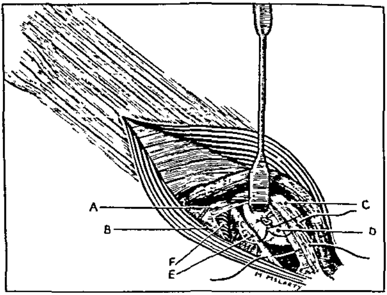

Fig. 2020.—The high operation for femoral hernia. The neck of the sac has been ligatured, one stitch has been passed from the conjoined tendon to Astley Cooper's ligament, and a second is being passed. A third will be required nearer the femoral vein.

A. Transversalis fascia.
B. Poupart's ligament.
C. Conjoined tendon.
D. Peritoneum, with stump of sac.
E. Astley Cooper's ligament.
F. Femoral vein.

tied by the emerging neck (see fig. 2019). This neck is quickly defined by blunt dissection, seized in a pair of stout forceps, and worked through into the inguinal incision. Here it is essential to disturb the fibrous surroundings of the neck as little as possible, but by gentle pulling while the tissues round it are slowly pushed down, aided at times by a pull in the reverse direction on the forceps which clamp the divided sac in the thigh, liberation will be accomplished with a minimum of trauma. The neck, when free, is pulled up into the wound, its inner side is examined for adherent bladder, it is opened, and any adherent omentum is cleared; finally, it is ligatured flush with the peritoneum, and cut away. There is no need to divide the neck just beyond the ligature; indeed, a long stump which will become fibrous tissue and form a gigantic septum crurale pushing the peritoneum well away from the crural opening is clearly an advantage.

(3) *Plugging the crural canal.*

(*a*) *With the sac.* Saunders Melville (*B.M.J.*, 1935, I, 467) divides the sac above the crural canal from within the abdomen, as described in section I*b* above, but first makes a small incision into the parietal peritoneum to see that the neck is empty. He does not remove the fundus of the sac. After closing the communication with the abdominal cavity by suture, he passes a pair of artery forceps into the sac from above Poupart's ligament, grasps the fundus, and inverts it into the abdominal cavity. Here it is obliterated and transformed by a few sutures into a flat plug, which he likens to the head of a rivet, and which effectually shields the weak area.

(*b*) *By auto-transplants.* Many substances have been advised: pedicled flaps of muscle from the pectineus or sartorius, of fat from the subcutaneous layers in the neighbourhood, or of the saphenous vein, divided low down in the thigh and curled up in the canal, and free transplants of fat, muscle, or costal cartilage.

III. The Low Operation

(1) *The skin incision.* The crease incision is entirely satisfactory for the low approach. More direct access is obtained by one immediately over the swelling, either below and parallel to Poupart's ligament, or starting half an inch above it and carried vertically downwards over the saphenous opening.

(2) *Isolation and ligature of the sac.* The methods for finding the sac which are advised in the standard operation are equally applicable to the low one. It is necessary, however, to isolate the neck as high as possible; this is done by gentle traction, while the fibrous tissues which surround it are snipped close to its wall with scissors and pushed up with their closed points. When it appears that the actual neck has been reached the sac is opened, emptied, tied off as high as possible and cut off. The stump is then pushed up the femoral canal out of sight.

(3) *Closure of the femoral ring.* It is unnecessary to discuss in any detail the many methods that have been suggested for closing the femoral channel from below, since, while their number is great, they differ in detail only and none is really satisfactory. The majority rely upon the suture of Poupart's ligament alone, or of Poupart's ligament and the falciform ligament, to the pectineus fascia. Marcy used a simple purse-string which entered Poupart's ligament near its inner end, and passed through Gimbernat's ligament, the pectineus fascia and as much of the femoral sheath as appeared to be safe, emerging again through Poupart's ligament near to its point of entry (fig. 2021, top).

Bassini inserted a series of interrupted sutures, the first two or three passing from Poupart's ligament to the pectineus fascia, and, before these were tied, another series from the falciform ligament to the same fascia (fig. 2021, bottom). Lockwood advocated a similar method but, by using a hernia needle and protecting the vein with a finger in the canal, he inserted the stitches into Cooper's ligament above. Other

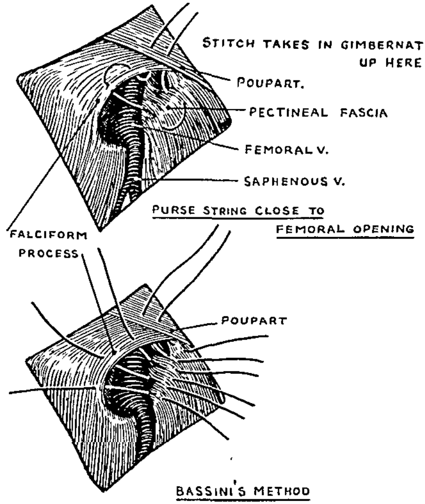

Fig 2021.—THE LOW OPERATION FOR FEMORAL HERNIA; CLOSURE OF THE CRURAL CANAL. (*Top*) THE PURSE STRING METHOD. (*Bottom*) BASSINI'S METHOD.

surgeons attempted to anchor Poupart's ligament directly to the pubic bone. Roux attained this end by driving a metal staple over the ligament directly into the bone, and Nichol of Glasgow by using a mattress suture passed through two holes drilled horizontally in the pubic ramus.

IV. THE EXTRA-PERITONEAL OPERATION

A. K. Henry, in the paper previously quoted (*Lancet*, 1936, I, 531), describes an extra-peritoneal approach to the femoral region, using a mid-line incision. The first case upon which he operated was

one of bilateral hernia in a girl. He writes: "I separated the recti at and below the navel, and stripped the unopened peritoneum from the sides of the bladder and from the pelvic wall. This at once gave a notable view of both hernial sacs, which stood out from the peritoneum like horns from a snail, and passed into the femoral rings" (fig. 2022). Henry delivered the sacs from the canals by blunt dissection, and ligatured them at their origin. He closed the canals by turning up a triangular flap of fascia, pedicled in front, from the pectineus muscle

Fig. 2022.—Henry's extra peritoneal approach for femoral hernia; to show the sac drawn out from the crural canal, the femoral vessels, and the cord passing out through the internal ring.

and suturing it to Poupart's ligament. He points out that a similar flap might be raised, and hinged behind at Cooper's ligament, which would avoid the possibility of a fresh hernia burrowing into the muscle itself.

Henry's exposure appears to be excellent, and through it any other method of repair could be carried out with equal facility. Thus the sac, if large, could be emptied from above and divided at its neck, avoiding the need to drag a bulky mass through the canal. The conjoined tendon could be sutured to Cooper's ligament with greater ease and with greater safety as regards the iliac vein than it can be through the inguinal incision.

CHAPTER IV

Rare Herniæ in the Pelvic Region

The varieties of herniæ through the abdominal wall are almost unlimited. Wherever vessels or nerves pass out, wherever muscles arise or are inserted, wherever fibrous intersections or septa occur, a pouch of peritoneum may be forced out by excessive, prolonged, or oft-repeated intra-abdominal pressure. It is quite beyond the scope of any work other than a monograph on hernia, to deal with these freak abnormalities in a degree of detail that would be of value to the post-graduate student. There have been, fortunately, surgeons who have devoted years of patient research to the collection of every possible fact relating to these uncommon conditions, and the result of their labours is available in any public library. These rare herniæ are, in any case, seldom seen unless they are strangulated, and no surgeon goes into the operating theatre to deal with an emergency primed with text-book maxims ; he is guided by general surgical principles, which his common sense and experience apply to the particular problem on hand.

Among such rare herniæ are those through Petit's triangle ; sciatic herniæ, above and below the pyriformis muscle ; perineal herniæ, which pass through defects in the pelvic floor at the point of exit of vessels or through gaps in the levator ani muscle ; and obturator herniæ. Of these only obturator hernia is reasonably common.

An obturator hernia passes through the obturator canal, the channel which is left at the upper part of the obturator foramen for the passage of the nerve and vessels into the thigh. The remainder of the foramen is closed by the tough thyroid membrane, which in turn is covered on its outer and inner aspects by the obturator externus and internus muscles. The pectineus muscle lies immediately in front of the crural end of the canal. The hernia is six times as common in women as in men, and in the former appears, like femoral hernia, to be the result of pregnancy.

The diagnosis of obturator hernia is seldom made on clinical grounds. Occasionally a woman complains of an intermittent swelling on the inner side of the thigh, and may state that its appearance is accompanied by gurgling sensations, disturbances of micturition, or pain down the

inner side of the thigh. Upon examination in such a case, an indefinite swelling may be seen in Scarpa's triangle, lying to the inner side of the femoral vessels, in the same place as a femoral hernia but much less definite in its outline. Palpation will reveal a bulge, which becomes less distinct when the muscles are contracted, and will possibly elicit tenderness. Vaginal examination may allow the actual opening to be felt, and will in any case disclose tenderness at the neck if a hernia is present. Pain referred down the branches of the obturator nerve is very characteristic.

In most cases the hernia is unsuspected till strangulation occurs, and even then no diagnosis is possible beyond that of intestinal obstruction of unknown origin.

Operation on an obturator hernia may be performed from the thigh or from the abdomen. The low approach is through a vertical incision. The interval between the pectineus and adductor longus muscles is separated, and if this does not give sufficient access, the pectineus is cut across close to its origin. This route allows direct exposure of the sac, but not reduction of gangrenous or adherent gut, high ligature of the sac, or satisfactory repair of the opening. For these reasons the abdominal approach is preferred by most surgeons. The sac is emptied, and can then usually be inverted into the abdomen. Satisfactory closure of the opening—a rigid aperture between ligament and bone which transmits nerves and vessels—is by no means easy. The simplest course is to plug the canal with a free transplant of fat, muscle or costal cartilage, before closing the neck of the sac. The inverted fundus may also be folded on itself by sutures to form a "rivet head," after the method recommended by Saunders Melville for femoral hernia (see page 3678).

CHAPTER V

Umbilical Hernia

The umbilicus is the scar left by the sloughing of the vascular pedicle whereby the fœtus obtained its nourishment in intra-uterine life. It marks the spot where, during the early stages that retrace the history of the vertebrate stock, changes of the most astounding nature have taken place. The human fœtus, when first recognisable, has an umbilical hernia so large that it would be more accurate to describe the whole as a hernia with a small embryo attached. This cavity, continuous with that of the abdomen and lined by the same peritoneum, contains the yolk sac and the fundus of the bladder known as the allantois. Yolk sac and allantois disappear early, and by the fifth week the umbilical diverticulum becomes occupied by the mid-gut loop, which has entered this " annexe " because too many other things are happening in the abdomen at the time to allow it room to develop. The mid-gut loop increases in length in this extra-abdominal pouch, and acquires that sharp demarcation between large and small gut which is marked by the ileo-cæcal angle. By the beginning of the tenth week, the abdomen once more has room for the whole alimentary canal, and the mid-gut loop returns to the main cavity through the umbilical orifice, now considerably reduced in size ; this return occurs remarkably *rapidly, and is complete by the end of the eleventh week. The* extra-abdominal cavity is now no longer required as such, the extra-cœlomic pouch of peritoneum disappears, and from the twelfth week till birth the umbilicus remains a well-defined ring in the abdominal musculature transmitting vessels only, two umbilical arteries and a vein. The reader who wishes to supplement this very brief résumé is referred to Keith's *Human Embryology*, or to Dott's article in the *British Journal of Surgery*, 1923, XI, 251.

At birth the umbilicus carries the umbilical cord and placenta. The skin is continued about half an inch along the cord, whose vessels are thenceforward covered only by Wharton's jelly and amnion. The cord being ligatured, that part outside the abdomen sloughs, and the scar is rapidly covered by a growth of skin from its edges. The umbilical vessels thrombose as far as the next functional channel within the

abdomen, and the clot in their lumen is rapidly converted into fibrous tissue by the ordinary processes of repair. During the first few weeks after birth, then, the umbilical scar consists of a firm ring surrounding a space filled by vascular organised clot, and is by no means strong. After six months the whole scar is a tough fibrous sheet, possibly the strongest spot in the abdominal wall.

In the adult the umbilicus marks about the centre, and the transitional point, of the linea alba. Above it the rectus muscles are separated by a space perhaps half an inch wide in the young and muscular, a space bridged by a felting of aponeurotic strands running chiefly in the transverse direction; below, the recti are in contact, and are divided only by a thin fibrous septum. On the posterior surface the umbilicus marks the meeting-point of three peritoneal folds, drawn out by the fibrous strands of the obliterated vessels as they are left behind in the process of growth; fat is often deposited in these folds, making them into pendulous fringes. The peritoneum at the umbilicus is fixed pretty firmly to the fascial planes.

TYPES OF HERNIÆ

Three separate varieties of herniæ occur at the umbilicus—the congenital, the infantile, and the adult—of which only one is truly umbilical. The congenital herniæ are not umbilical because they arose before, and prevented, the formation of an umbilicus, while the adult ones, except for a small minority, are not protrusions through the umbilical scar but above it—that is, they are para-umbilical.

I. Congenital Umbilical Hernia

A congenital defect remains at the umbilicus either when the *mid-gut loop fails to return to the abdominal cavity in the tenth week* of intra-uterine life, or when, though it has returned, the extra-cœlomic pouch of peritoneum fails to close. The failure may be of any degree, but for practical purposes two varieties may be described:

(*a*) *Complete exomphalos.*

In some cases the protrusion is ruptured during delivery, and the infant is born eviscerated. When this does not occur, the abdominal wall appears to be replaced by a greyish translucent dome, moulded into a series of knobs by the underlying viscera which can be faintly seen through it, the cord being attached to the summit. The abdominal wall lies well back in the flanks at the sides of the swelling, and the junction between abdomen proper and exomphalic swelling is marked by the sudden transition from pink skin to grey Wharton's jelly.

The coverings of the swelling are amnion, Wharton's jelly, and extra-cœlomic peritoneum. Its contents are in any case those parts derived from the mid-gut loop, the small intestine and proximal colon, with the addition in many cases of the greater part of the liver and some of the stomach and pelvic colon. These parts are seldom normal: the mid-gut loop is usually unrotated and unfixed, and the liver, unsubjected to the mutual moulding forces of intra-abdominal development, is a globular mass.

Exomphalos occurs in about one birth in ten thousand, and may be associated with other defects such as spina bifida. Two cases came under my care when I was a surgical registrar, and by one of those coincidences which are so common in surgery, both were admitted into the same ward in Guy's Hospital within six hours of each other. The first, which was under my late chief, Mr. R. P. Rowlands, was operated upon by me and later shown at the Royal Society of Medicine (W. H. Ogilvie, *Proc. Roy. Soc. Med.* (Clinical Section), Dec. 1921); he developed double inguinal hernia a year later, which was also repaired, and when last seen he was a healthy boy of twelve with a sound abdominal wall. The second case, under Mr. L. Bromley, already showed signs of peritonitis on admission and died shortly afterwards.

Treatment. Exomphalos is a surgical emergency, because the coverings of the swelling have no blood supply apart from that derived from the umbilical cord which ceases at birth. Unless the abdominal cavity can be closed with living tissues before it becomes infected, death is inevitable. Fortunately the abdominal wall is not deficient, but merely displaced.

An incision should be made rapidly round the junction of living tissues with Wharton's jelly, care being taken to preserve every bit of skin. The edges are undercut and turned out on each side for about an inch, to expose the underlying aponeurosis. The abdominal cavity is then opened at any point, and by rapid dissection with the finger, the coverings are separated from the viscera, and the edges of the mesoblastic defect made plain. The whole grey mass is then cut away, and a number of Ochsner forceps clamped on the edges of the abdominal wall on each side, and pulled together to approximate them. A series of tension sutures of salmon-gut guarded with rubber tubing are passed from side to side through skin and abdominal wall, and their ends are clamped. The edges of the defect are then approximated by interrupted sutures of No. 1 chromic catgut. If the condition of the child is entirely satisfactory, it is better to incise the rectus sheath for its full length on each side (see reconstruction operation under infantile hernia)

and to close the walls in two layers. The skin is approximated by a continuous suture, and the tension stitches are tied over a roll of gauze.

(*b*) *Congenital hernia into the cord.*

In this condition a peritoneal pouch of varying size extends from the abdominal cavity into the root of the umbilical cord, which may be expanded or of nearly normal appearance. The importance of such a hernia lies in the risk of a loop of bowel in the sac being included in the ligature applied at birth. Even if this does not happen, the same dangers remain as are inherent in exomphalos—that the coverings of the sac are non-viable. Every case should therefore be subjected to operation at the earliest possible opportunity. The method of repair will follow the general lines which have been laid down for the treatment of exomphalos, but the task of the surgeon is naturally a much simpler one, and the operative risk is less.

II. Infantile Umbilical Hernia

An infantile umbilical hernia is an acquired defect due to stretching of the newly formed cicatrix before it is strong. It is not therefore seen in the first few days after birth, and is very unlikely to appear after the sixth month. Some factor causing an increase in abdominal pressure, either constant or intermittent, is usually present; the infant on whom the blame cannot be laid for crying, coughing, phimosis, constipation, or tympanites is indeed a prodigy. The protrusion is rarely more than a small knob-like swelling the size of the last joint of a finger, and the fibrous ring of the abdominal wall proper is rarely stretched. These infantile herniæ are usually empty when the child does not strain, and very rarely become irreducible. They can be retained by a simple pad, and with this treatment the great majority are cured in twelve or at the most eighteen months. After this period repair by natural means is unlikely.

Treatment.

(1) *The incision.* Since the defect is a very small one in an abdominal wall that is perfectly sound up to its margins, only limited access is required. To remove the umbilicus is unnecessary mutilation, and thoroughly bad psychological if not surgical treatment, for it often leads to a pronounced sense of inferiority. A flap incision which preserves the cicatrix while giving access to the hernial opening should therefore be used. For many years I advocated a curved incision below the umbilicus, but I have now replaced this by a transverse one about an inch above it. If the surgeon studies the abdominal wall of a series of healthy young adults, both men and women, he will find three flexion

creases in almost constant positions; first, the suprapubic crease discussed in the inguinal section, which extends the whole width of the trunk; second, a shorter one with a more open curve about half-way between the pubis and umbilicus; and third, a straight one crossing the epigastrium a short distance above the umbilicus. The second is too low for an umbilical approach, the third is ideal (see fig. 1985).

The incision is carried down to the aponeurotic layer, and the lower flap is then dissected off the sac and surrounding sheath, to one or one and a half inches below the opening. The sac is pulled up, and the fibres which surround its neck are divided carefully with scissors or a sharp knife; as the fibres are cut, more and more sac will come out

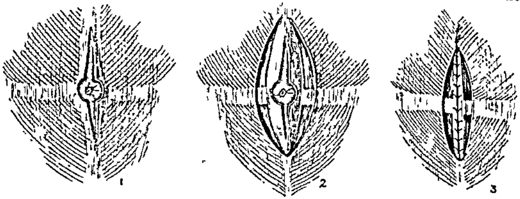

Fig. 2023.—THE RECONSTRUCTION OPERATION FOR UMBILICAL HERNIA.

1. THE SAC TIED OFF, THE OPENING ENLARGED BY INCISIONS UPWARDS AND DOWNWARDS IN THE LINEA ALBA.
2. THE RECTUS SHEATH OPENED ON EACH SIDE TO EXPOSE THE RECTUS MUSCLE.
3. THE TWO INNER MARGINS SUTURED TO FORM A POSTERIOR RECTUS SHEATH; COMMENCING SUTURE OF THE ANTERIOR LAYER.

till a good collar of peritoneum is free. The sac is then opened, emptied, tied off at its neck with a single ligature, and cut off.

(2) *Closure of the ring.* (*a*) In the usual hernia the defect is a small one, which can be repaired by simple suture. A purse-string of No. 1 catgut on a small, curved needle is first passed through the aponeurotic layer a few millimetres outside its margin; when tied, this buries the peritoneal stump and closes the hole. The weak area is further reinforced by three or four stitches, passed through the rectus sheath each side, which infold and bury the previous suture. The skin incision is closed with fine salmon-gut or Michel clips.

(*b*) If the ring has been stretched, a reconstruction of the rectus sheath is advisable. The opening in the aponeurosis is first elongated by incisions extending from its upper and lower margins into the linea alba for about $\frac{3}{4}$-inch. The rectus sheath on each side is opened along the whole length of this enlarged defect by a cut close to its margins, thus providing two aponeurotic edges, which, sewn together, constitute an anterior and posterior rectus sheath (fig. 2023).

III. The Umbilical Hernia of Adults

A small number of umbilical herniæ in adults are the reappearance of infantile ones thought to have been cured, which have again been rendered patent by the pressure of ascites or pregnancy. The great majority are acquired defects of the linea alba just above the umbilicus. They rarely appear before the age of twenty-five, but then become increasingly common till about the age of fifty, after which few new ones are reported. It will be noticed that this age span corresponds closely to the child-bearing period, and it is in women who have had children —usually many of them—that these herniæ are typically seen. Next to pregnancy, fat appears to be the most common cause, and in men about the only one.

An adult umbilical hernia is rarely seen when it is small, because it is then hidden in the general layer of fat covering the abdominal wall. When first noticed it is usually an oval swelling, with its greatest diameter in the transverse plane, and carrying the umbilical cicatrix below its centre. Such swellings usually increase rapidly in size. The skin over them becomes thinned. The umbilicus is stretched transversely so that its edges are approximated, and secretions collect and fester in its deeper parts. The fold below them becomes moist and eczematous. The margins are indefinite, because the surrounding fat does not allow an examining finger to reach the opening in the aponeurotic layer.

The sac is at first lined with peritoneum, but because the serous membrane is fixed to the abdominal wall at this point, further enlargement cannot be accompanied, as it is in other herniæ, by borrowing more peritoneum from that inside the abdomen. The coating splits and gives way in an irregular manner. In all the larger umbilical herniæ the sac wall is fibrous, much loculated, and lined by peritoneum at its neck alone. Hence adhesions form early, and the contents are reducible in part only, if at all. An adult umbilical hernia always contains omentum, usually transverse colon, and often some loop of jejunum.

Treatment. It has already been pointed out in the introductory section that a truss is generally useless in these cases, that strangulation is common and dangerous, and that operation is usually advisable even though the patients are poor subjects for any such ordeal. On these last grounds local anæsthesia will often be advantageous. The umbilicus should always be excised; the patients are old ladies, too fat and ugly for cosmetic surgery, too placid for complexes, and too eptic to allow the retention of infected loculi.

(1) *Reconstruction of the abdominal wall.*

In the case of small herniæ through a sound abdominal wall, such as those which represent the persistence of an infantile defect, the form of repair recommended for the larger herniæ of childhood should be adopted. The skin incision takes the form of a vertical ellipse, excising the navel.

(2) *Mayo's operation.*

The transverse overlap method, introduced by W. J. Mayo in 1893 for the radical cure of umbilical herniæ, is one of those rarities in surgery—a procedure that has remained unchallenged and unimproved since its introduction. It is founded upon the physiological concept that the aponeurotic planes of the mid-line of the abdomen are the tendon of insertion of the lateral muscles, and that the pull they resist, and therefore the strength of their fabric, is transverse. An overlap in the vertical plane is against the lines of stress, but one in the transverse plane is with them, and therefore secure.

(*a*) *The skin incision.* This is a wide transverse ellipse surrounding the umbilicus, extending up and down to include an amount of subcutaneous fat that may be considered redundant, and laterally, at any rate as far as the mid-point of the rectus muscles. The incision is immediately deepened to the aponeurotic layer, and the subcutaneous tissue is then dissected inwards off this layer till the fibrous neck of the sac is exposed.

(*b*) *Treatment of sac and peritoneum.* The whole mass of skin, fat, and hernia, is held up while the neck is gently cut round with knife or scissors (fig. 2024, 1). As the fibrous layers are divided, others appear and are snicked, till the peritoneal tube is entirely free of its aponeurotic sheath. The sac is opened at the same level—the neck, for here only is it likely to be free from adhesions. A finger or blunt director is introduced through the opening, which is then enlarged till the interior of the sac can be viewed, and the contents pulled out if sufficiently free; by working from neck to fundus, from free space to adhesions, this clearance can be done safely. Omentum may be ligatured and cut off; and intestinal loops must be freed, either by continuous dissection, or by snipping round the bits of sac which adhere to them and leaving them on their walls.

When the contents of the sac have been replaced in the abdomen, it is necessary to decide whether the peritoneum should be closed as a separate layer, or with the rectus sheath. If the opening is not more than 3 cms. across, the peritoneal

edges should be carefully dissected free from the abdominal wall on each side, and the hole closed by a running stitch. If the opening is larger, peritoneum and rectus sheath may be overlapped together.

(c) *Repair of the aponeurotic layers.* The opening in the linea alba is extended on each side by incisions carried outwards through all layers till they expose the inner border of the rectus; roughly circular before, it is now a transverse ellipse. The lower flap is

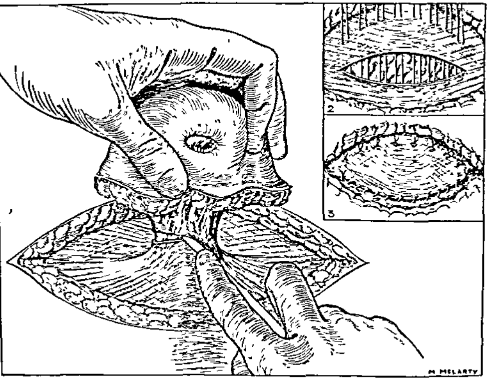

Fig. 2024.—MAYO'S OPERATION FOR UMBILICAL HERNIA.

drawn under the upper one by a series of mattress sutures of stout catgut. The first is passed through the upper flap near the mid-line and about two inches from its free edge from without inwards, a finger protecting the abdominal contents; then through the lower flap from within outwards, ½-inch from its edge, back through the edge of the lower flap; and once again through the upper one from within outwards, half an inch to the side of its point of entry (fig. 2024, 2). Other mattress sutures are similarly inserted on each side of the first, their distance from the upper margin of the opening decreasing as they near its lateral limits. When all these sutures are tied, the lower flap is pulled up under the upper as a wide tongue. The free

edge of the upper flap is now fixed to the aponeurosis below the opening by a continuous catgut stitch (fig. 2024, 3). When the recti are not widely divaricated, lateral cuts to their margins may not give flaps sufficiently wide for an overlap; in such a case the cuts may be extended further outwards through the anterior rectus sheath only, and this part alone be included in the more lateral of the overlap mattress sutures.

After attention to hæmostasis the skin and superficial layers are closed by the usual methods.

(3) *Very large herniæ.*

When the defect is so large that the Mayo overlap method cannot be performed without undue tension, or when, as sometimes occurs, the hernial opening is not one but two or three adjacent defects in the linea alba, the method of fascial suture should be employed.

IV. Epigastric Hernia

The ætiology of epigastric hernia seems to be identical with that of the para-umbilical herniæ of women, a protrusion through a chink in the felting of the linea alba above the umbilicus usually preceded by an extension of extra-peritoneal fat; the clinical picture is, however, entirely different.

Epigastric herniæ are usually seen in men under forty. They occur in the mid-line, about half-way between the xiphisternum and the umbilicus. They are usually small, not often exceeding a hazel-nut in size, and in many cases cannot be seen, but only felt. They are soft, giving the impression of a lipoma, and are often tender. Few of them give any impulse on coughing or contain anything which can be reduced, yet at operations the great majority are found to have a small peritoneal sac in the fatty lump. They chiefly attract attention because they cause pain—local pain in the lump, or indigestion of the duodenal ulcer type. This last has two possible explanations, the mechanical, suggesting interference with the contractions of the pyloric antrum during the later stages of digestion by a bud of gastric omentum nipped in the hernia, and the physiological, which accounts for the pain as a gastro-peritoneal reflex (see also Vol. I, page 207).

The defect should be repaired by a longitudinal reconstruction operation. It is always wise at the time to ascertain by inspection that the duodenum and gall-bladder are really normal, and to remove the appendix if this can be done without enlarging the incision.

use in the tough edges of an old scar, where they hold admirably. One layer of sutures will be used to approximate the edges, and a second may be inserted, taking a bite of the aponeurosis half an inch further out, a layer which reinforces the first and relieves it of all strain.

(3) *The repair of a really large incisional hernia.*

Defects are sometimes encountered which are so old and so wide that

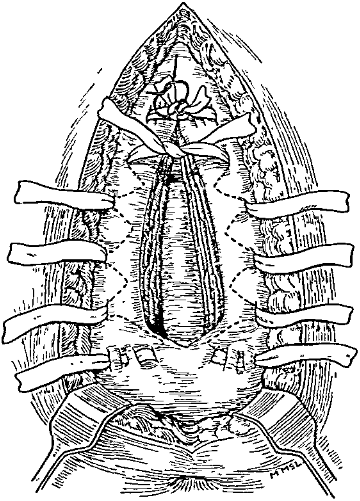

Fig. 2025.—Gallie's "many tailed" fascial transplant for large hernia.

no amount of pulling will approximate the edges. Here Rehn's dermal patch transplant (see page 3609), reinforced if necessary by fascial strips, will provide a way out of the difficulty. Gallie advocates large fascial transplants, cut like a many-tailed bandage, for the repair of these big openings. He writes: "As a rule two patches of fascia, five inches by three and one-half inches, can be obtained from the lateral aspect of a single thigh. The ends of the patches are then split into strips about one-quarter of an inch wide and by means of a fascia needle passed

through the edges of the ring as shown in figure 2025. If a second patch is needed it is laid edge to edge with the first and the two are sewn together with a fine strip of fascia lata threaded on a needle. At the ends of the opening, special precaution is taken to weave the tails into the edge of the ring so as to prevent a protrusion over the end of the fascial sheet. When all the tails have been drawn through the abdominal wall they are tied together, each to its fellow of the opposite side, and the edges of the opening drawn together as closely as seems safe. If they can be brought into contact without too much tension, so much the better, but if they cannot, the surgeon may rest assured that the deep side of the defect in the abdominal wall has been permanently closed off. Often it is possible, where the deep portion of the opening cannot be drawn together, to close the anterior rectus sheath with catgut or a suture of fascia and this shuts off the sheets of fascia from view and seems to be an advantage. Care should be taken to oversew the knots in the tails of fascia with catgut as these have a strong tendency to slip and untie when strain is put upon them."

PART XIX
PLASTIC SURGERY

by
T. Pomfret Kilner

PLASTIC SURGERY

CHAPTER I

Introduction and Technique

It is my intention to describe here those procedures which, thoroughly tried out on the mass of cases of disfigurement and deformity which formed the aftermath of the European War, have been found applicable to civil practice, and to add such developments as have been made in them; other procedures, of a more purely cosmetic nature but owing their origin to the same work, will also be put forward.

It would seem redundant in a work of this class to write any lengthy historical introduction; reference to almost any of the many books on special branches of this subject will provide such historical details. It will perhaps not be amiss, however, to remind readers that plastic surgery is a very ancient art, and that for centuries attempts have been made to reconstruct parts lost by accident or disease and to supply or correct features missing or deformed from congenital abnormality.

It would appear reasonable to summarise the development thus: plastic surgery was born centuries ago. It was still a puny ill-nourished child when the European War broke out. It received such abundant and concentrated nourishment in the post-War period that it grew with abnormal rapidity, and has now become a fully developed adult speciality which has absorbed many of those odd branches of surgery previously tackled only occasionally, and often in very indifferent manner by the general surgeon.

GENERAL TECHNIQUE

No branch of surgery teaches so clearly the necessity for gentle atraumatic handling of tissues. Every point of crushing is a point of potential necrosis. To avoid this, skin flaps or grafts are treated with the greatest respect, and as finger manipulation is less damaging than even the gentlest instrumental "handling," the instrumental aseptic technique of the orthopædic surgeon finds little place in surface work. Fine tissue hooks (fig. 2026), used not as retractors but as a means of holding and manipulating, are employed whenever possible. Forceps of the fine-toothed variety (Waugh's tonsil forceps) are employed where

hooks prove impracticable, but even these fine prehensile instruments are used with only the gentlest pressure on their points. When a skin graft or flap has to be handled as a whole, it is held by the fingers in a moist gauze swab. When grafts of deeper tissues—bone, cartilage or fascia lata—are being taken. aseptic technique and instrumental handling come into their own, and wound-edge protection to prevent contact with skin is employed.

Incisions

In an effort to minimise scarring, many different forms of incision have been tried. None has proved more effective in this respect than the clean cut produced by a scalpel with a really sharp edge applied at right angles to the skin surface.

In plastic work the position of an incision is frequently dictated by some pre-existing scar which calls for excision. Where this is not so, all incisions, particularly about the face and neck, are made to follow the

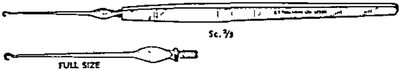

Fig. 2026.—Kilner's fine skin hook with detachable handle.

well-known skin tension lines described by Langer in 1861. (*Wien. Wchnbl.*, XVII, 20, K. Akademie der Wissenschaften, Wien, 1861, and *Roy. Soc. Med. Tracts*, Vol. 58, 19.)

Suture Materials and Suturing.

Skin suture material should be as fine as possible. It should not possess hygroscopic characters. Horse-hair, silk in one of its many forms, waxed or otherwise, and artificial silkworm-gut have all been tried, but the finest gossamer silkworm-gut has proved the most generally useful. Although only a small point, it is often a very important and yet overlooked one that fine suture material should always be dyed a distinctive colour, or the removal of sutures becomes a most difficult procedure. Overlooked buried pieces of colourless unabsorbable suture material have many times been discovered as the cause of disfiguring scar thickening or of persistent reaction in otherwise healed wounds.

There is no question about the advantages of having all such sutures attached to eyeless (atraumatic) needles, and it is only the expensive nature of these which would persuade the surgeon who had tried them to abandon their use on any occasion. They produce the minimum of trauma at the point of perforation, and as they pass through the skin

smoothly and without drag they call for less forcible holding of the skin by the forceps in the other hand. It stands to reason that the shorter the needle compatible with the work in hand the better, for there is bound to be some irregularity of action in drawing the needle through the skin, and the longer the needle the more this will show itself on the opening made. For most purposes eye-curved needles of sizes 3 and 6 are sufficient—the improved pattern needle of this class, which is slightly flatter in the shank, is less liable to slip round in the needle-holder. Where expense or other factors contra-indicate the use of atraumatic needles, similar fine needles of the eyed variety should be used. For heavier work curved needles size 18 are employed, while, where scarring is of secondary importance, e.g., in approximating edges of abdominal wall defects after removal of flaps, still larger needles (size 8) are used. For deep tissue approximation by catgut, fine half-circle needles (Fistula-fine 8) have proved useful, though occasionally here also an atraumatic needle may be indicated. There are situations where skin or mucous membrane edges have to be approximated and where sutures cannot be removed, inside the nose for example or in the reconstruction of the urethra, and in such situations the atraumatic needle threaded with fine catgut is essential.

Type of Suture

Endless varieties of suturing methods have been advocated, and each may find some special application. In skin suturing, however, the chief aim should be full-thickness skin-edge approximation, and any suture which will provide this in the particular situation under treatment should be used. In most situations interrupted skin sutures give the most perfect apposition. A nice judgment is required as to the distance apart to place these, more particularly so when some scar tissue must be left behind and the wound edges do not tend to fall naturally together as in fresh skin incisions. The end-on (vertical) mattress suture is, in my opinion, a most valuable stitch, for it gives perfect apposition of the deeper layers of the skin and at the same time ensures cuticular approximation. In its continuous form (see fig. 2027) it is probably the most frequently used suture.

Subcuticular sutures of absorbable material have their distinct uses for approximating deep tissues and for relieving tension on the skin suture line, but as a means of skin approximation they cannot be expected to give such good scars as those which give whole skin apposition. The subcuticular skin stitch, more correctly an intradermal stitch, has its special use in situations where it would be difficult to remove a large number of interrupted sutures or points of a continuous

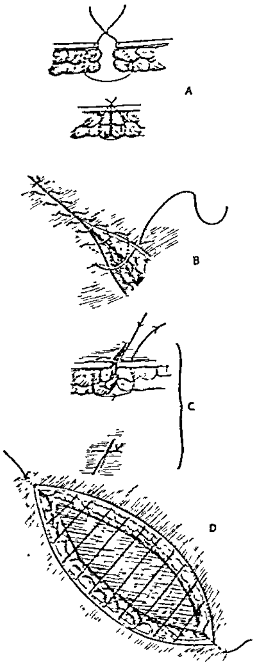

Fig. 2027.—Methods of suturing.

A. Interrupted suture taking full bite of deep tissues but entering and emerging close to the skin edge. A suture of this type gives broad wound-edge approximation with a minimal risk of stitch scarring.

B. Continuous end-on or vertical mattress suture. This gives broad wound-edge approximation and ensures accurate apposition of skin edges without inversion.

C. Interrupted end-on or vertical mattress suture.

D. Subcuticular or intradermal suture.

external one. In incisions in the retro-auricular furrow, for example, the ear has to be rolled forward for the removal of external sutures and this tends to drag open the newly-healed wound. An intradermal silkworm-gut suture in this region is readily removed from above or below without disturbing the lie of the ear. Again, in suture lines in the eyelids the repeated approach to the eye of scissors and forceps distresses the patient greatly, while the drawing out of an intradermal suture at the side causes very little discomfort.

In other situations it has been found that the intradermal suture often gives a false and flimsy epidermal approximation over a linear blood collection, a "blood blister" as it were, and the resulting scar, instead of being less obvious, is definitely wider. After all, the main object of the intradermal suture is to avoid scars from external sutures. If external sutures are placed near to the wound edge, are removed as soon as they have done their work (3–5 days), and if some dressing, e.g., collodion gauze, is then applied which will prevent early stretching of the scar, they provide the best and surest means available.

A very large number of other means of approximating wound edges has been suggested; some are impracticable in the general run of cases but each may find applicability to a special case.

Removal of Sutures

The removal of sutures may prove even more difficult than their insertion if damage to the newly-healed suture line is to be avoided. Fine non-toothed forceps of the type designed by McIndoe, and sharp-pointed scissors, thin at their ends, are essential. It is well to use short-shafted scissors, for there is no such thing as a perfectly steady hand, and any movement in the fingers is considerably multiplied at the end of a long instrument. Good lighting and, more particularly in young infants and nervous apprehensive adults, efficient assistance to steady the part are important. The removal of small fine sutures should be a carefully planned and deliberate undertaking and there should be nothing of "struggle" character about it. Preliminary sedation is seldom required except in small children who are frequently more troublesome than either young infants or adults. The importance of coloured suture material in this connection has already been stressed. Without it, it is the easiest thing in the world to cut off the whole external part of a suture and leave its deeper part buried. It is frequently not realised that scissors which do not cut at their actual points are useless for this work; the point of the scissors cannot be inserted through the loop as in removing larger sutures.

In removing sutures from a newly-healed wound it is wise to begin by removing only alternate sutures. Only in this way can one be sure about the safety of removing the remainder. If the slightest separation of edges occurs it is wise to defer the removal of the remainder for another day or two. When all sutures must be removed particularly early, materials for preventing opening of the wound or stretching of the scar should be prepared beforehand. Half the wound may be protected in this way by the application of ribbon gauze or cotton wool soaked in collodion before the sutures are removed from the other half of the wound. The second half is then similarly protected. If sutures show signs of cutting into the skin surface they may be divided but not removed until some days later.

Two practical points which I have not seen mentioned elsewhere may be added before leaving this subject. The only part of suture removal which should produce any discomfort is the dragging out of the buried part of the stitch. In children especially it is a good thing to cut those sutures which are to be removed and to leave them for a moment. The patient, not having been hurt as he anticipated, gains confidence, and during the wait it will be found that the sutures have loosened themselves and can be picked out without pain. When

sedation has been used, again usually in children, it will be found that after the removal of several sutures the patient frequently becomes restless and resists further interference. The theory of the "summation of stimuli" in a more or less reflex animal probably explains this restlessness. A short pause gives a further period of peaceful suture removal.

CHAPTER II

Free Skin Grafts

The general surgeon should be prepared to cover any raw surface he produces; he should be prepared to carry out destructive operations, such as those for the eradication of malignant disease, unfettered by a fear of leaving disfigurement and confident that his operation can be planned in a manner calculated to avoid permanent deformity; he should be prepared to prevent those extreme contractures which so frequently come into the plastic surgeon's hands for correction; and he should be prepared to treat such conditions as ectropion before, and not after, loss of eyelid protection has resulted in corneal ulceration and opacity. For all these requirements he should know in more practical fashion than is usually the case how to make use of free skin grafts.

The parasitic quality of skin was demonstrated by Reverdin in 1869, though, centuries before this, reconstruction of the nose is said to have been carried out by means of free grafts from the skin of the buttock.

PINCH GRAFTS

Reverdin grafts are now seldom used, but their counterpart, the Pinch graft or small deep graft (Staige Davis)—epidermal at its margins and full-thickness in its centre—has a large field of usefulness in expediting epithelialisation in large granulating surfaces of the type produced by burns or by street accidents. The cosmetic result which such grafts give is usually poor and they leave disfiguring scars in the donor area. It is for this reason that they have found little favour in work about the face and neck.

Figure 2028 illustrates well the manner in which they are prepared and applied. A number of long straight cutting needles (Sim's abdominal) are employed. The donor area may be anæsthetised by local anæsthetic solution; the granulating surface seldom requires any anæsthetic, but it should be prepared beforehand by leaving off all antiseptic or greasy dressings for twenty-four hours before operation and applying simple saline gauze compresses. The grafts are cut by means of a No. 11 Bard Parker blade, the cone of skin being held up by

the point of the needle in the manner illustrated. A sawing or shaving action is employed in order to obtain a surrounding frill of epidermal graft. In order to avoid infection of the donor area the surgeon cuts the grafts and the assistant applies them, the needle returning from the recipient area being immersed in 1 in 20 carbolic acid solution and afterwards rinsed in saline before approaching the donor area again. These grafts should be roughly 0·5 cm. in diameter and should be firmly pressed down on the granulating surface, leaving intervals of about 0·5 cm. between them. Their epidermal frills should be carefully spread out by one needle while the other holds the graft in position. The grafted area is covered by some material which will not adhere but will allow free escape of secretions into the covering gauze dressing.

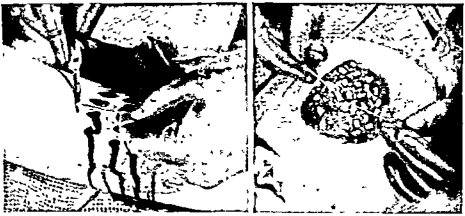

Fig 2028.—The cutting and application of Pinch or small deep skin grafts.

Tulle Gras, usually employed for this purpose, is an open mesh net material impregnated with vaseline containing 1 per cent balsam of Peru. It is prepared by Lumière of Paris and is supplied by the Anglo-French Drug Co. It has been found particularly suitable for dressing these areas. Previously, lint, spread or impregnated with vaseline, was employed but this provided a much too air-tight dressing, preventing the escape of serous or other discharge and converting the area covered by it into something of a hothouse in which organisms from the glandular elements of the surrounding skin appeared to thrive. Various modifications of the original material and instructions for its preparation for hospital use are described in an excellent paper by D. A. Beattie, published in the *Journal R.A.M.C.*, 1933, lx, 352.

The covering gauze is soaked in saline or in flavine and paraffin emulsion. The donor area is dressed in similar manner. It is a wise precaution to tack down the tulle gras over the grafts by a few marginal

sutures, picking up the surrounding skin to prevent shifting of the grafts during the application of the further dressings. When circumstances allow, it is a useful practice to paint the skin immediately surrounding the gauze dressing with mastisol and to apply an ordinary cotton bandage immediately. This helps materially in preventing any shift of dressings or grafts. Outside this, further absorbent material may be applied and snug pressure dressing provided by elastic adhesive strapping or crêpe bandage. The dressings are not disturbed for about five days unless constitutional symptoms or excessive discharge call for earlier interference. When grafting highly infected surfaces it is advisable to take down the dressing to the tulle gras layer earlier and to renew the outer gauze dressings after mopping away discharge. The majority of such grafts take completely and spread rapidly. Their appearance at the first dressing is characteristic: those which are living are pink and firmly adherent; those which have failed to take are grey or pearly white and will separate easily.

Drawbacks to this type of graft are: (1) Time taken in cutting and application; (2) Disfigurement produced in the donor area, for the scars tend to be keloidal; and (3) Poor cosmetic result in the grafted area.

Where large surfaces require grafting and where infection is not virulent, it is my practice to shave off granulations and apply sheets of Thiersch graft.

THE THIERSCH GRAFT

The credit for introduction of this type of graft is shared by Ollier and Thiersch, but it is convenient to call it by the name which has been attached to it for so many years. It was thought originally that it was composed only of epidermis, but it is impossible to cut a graft so thin that removal of deeper layers at some points is avoided.

When cut, a Thiersch graft should be uniform in thickness and should have the appearance of thin tissue-paper. It should leave a surface, with only tiny punctate hæmorrhages, on which epithelial growth is so rapid that healing is complete when the dressing is removed for the first time at the end of a week. It is in this respect that the Thiersch graft is so surgically economical; the donor area suffers little and may even be used again as the source of a graft at some later date, if necessary. The unpleasant keloid scars frequently encountered on patients' limbs, stated to be the sites from which Thiersch grafts have been taken, are evidence that many surgeons do not understand clearly what a Thiersch graft is, for it is obvious that the knife has penetrated deeply at some points or even throughout the graft. In the majority of

cases, Thiersch grafts are required to be hairless, and they are therefore usually taken from the inner aspect of the upper arm or the outer side of the thigh. The antero-internal aspect of the thigh is a difficult region from which to cut a good graft of uniform thickness and breadth, for it is impossible to place the limb in any position which does not leave an unpleasant and greatly-interfering muscular ridge. Unless it is immaterial whether the graft, in its transplanted position, does or does not grow hair, it is unwise to have the donor area shaved beforehand, for it then becomes difficult to decide what is and what is not hair-bearing skin. These remarks are made in spite of the fact that I am aware that, in theory at any rate, no Thiersch graft should carry with it hair follicles and, therefore, the capacity for growing hair. It is always well to be on the safe side and to avoid the necessity for removing, for example, those intra-oral beards which have more than once been seen following skin-grafting in the mouth.

Preliminary skin preparation should be carried out without pigmented antiseptics, and ordinary soap-and-water cleansing followed by methylated ether and then by alcohol has proved best for the purpose. At the time of actual operation a final wipe over with ether is all that is required; methylated spirit is inclined to make the knife slide less smoothly over the surface. When it is known beforehand roughly what area is to be grafted, it is as well to cut the graft first (and to cut it well over-size), in order to avoid the possible carrying of infection from the recipient to the donor area. Draping of the area should not be carried out in any slipshod fashion, for it should be considered "criminal" to infect the area from which the graft is cut.

At the risk of appearing to provide unnecessary detail, explicit instructions regarding preparation may be given, for there is no doubt that many a graft is doomed to failure from infection before it reaches its destination.

Experience has shown that there is only one completely satisfactory way of shutting off the arm area, and this is illustrated in figure 2029. The arm is held out from the body horizontally by a nurse for final skin preparation. A sterile towel is placed over the chest, level with the axilla and coming well down the side of the table. The upper arm is cleansed with ether as far as possible in this position. The arm is now raised to a vertical position, the already cleansed part coming into contact, if with anything, with the sterile towel and not with the blanket. The remaining surface of the limb is cleansed with ether, and two fresh towels, placed over the chest and face respectively, are clipped to the skin above and below, as in the illustration. A ring of mastisol is

painted around the elbow region, and a third towel is carefully draped over the hand and forearm with its upper edge fixed by the mastisol. A towel clip is inserted for greater safety. The nurse continues to hold the arm with the palm of the hand upwards during the cutting of the graft. She should not pull on the arm but should allow the elbow to be slightly flexed, while the upper arm rests on the knee of the surgeon whose foot is supported on a stool of convenient height.

Everything is now ready for the cutting of the graft. A sharp Thiersch knife or a newly-stropped razor, and a strip of wood with

Fig 2029.—Skin graft cutting by Blair knife preceded by wood slip. Arrangement of towels to shut off donor area.

smooth rounded edges, 8 inches by 3 inches and $\frac{1}{4}$-inch thick, are all that is required for the job. The under-surface of the knife or razor, and particularly its back edge, are smeared lightly with vaseline or liquid paraffin and one edge of the wood strip is similarly treated. Too liberal a supply of grease on the wood strip renders the skin surface of the graft unduly greasy and makes its later manipulation unnecessarily difficult.

SKIN GRAFT CUTTING APPARATUS

It is worth while diverging a little at this point to make some remarks on skin-grafting knives. There is little question that the best knife for the purpose is one of ample length prepared from wafer-steel of the pattern made by Tontrup of St. Louis, to the requirements of

Professor V. P. Blair. This knife has been copied in this country by Messrs. Down Bros. (fig. 2030) and is supplied with a very simple sheath which prevents damage to its edge when not in use. It is quite unnecessary and, indeed, disadvantageous to have such a knife ground and set after every operation. Blair himself employs a damp sterile towel smeared with sterile emery flour for stropping the instrument during the course of an operation, but the ordinary care which a man gives to his "cut-throat" razor for shaving purposes is all that is required to keep a graft-cutting knife in excellent condition for many months and for a very large number of operations. The knife should be carefully washed and dried after use and should be stropped immediately; it should also be stropped again immediately before use. It is best sterilised in lysol followed by alcohol, or in the latter alone. Expensive strops are supplied by most surgical instrument makers but none of these has been found one tithe so useful as a very low-priced three-sided strop, the Rosswaye Tri-side Strop, made and marketed by R. M. Ross, 26 Upton Road, Slough. The ordinary French razor made

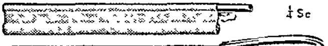

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Fig 2030.—The Blair skin-graft knife.

of soft steel, to which an excellent cutting edge can be given (even after considerable damage has been done to it) by a few strokes on such a strop, is eminently suitable for cutting smaller grafts, only its limited length precluding its use for larger ones. A special metal handle has been made for me for the French razor blades by Messrs. Thackray, which allows for the locking of the blade in the open position. The older, more expensive and heavier Thiersch graft knife can be kept in good condition in precisely similar manner, and at times one has felt that its weight and balance offer certain advantages.

The greased edge of the wood slip is applied transversely across the upper arm skin, just below the axilla, and its position is changed until a flat surface sufficiently broad for the required graft is produced. At one time a second wood slip was held above by an assistant, but this and all stretching or other manipulation of the skin were discarded many years ago, for these "helps" represent unknown factors and success depends upon a nice balance between the work of the two hands of the operator. In this procedure it is very essential that the right hand shall know precisely what the left hand is doing.

The knife now begins its work. It is applied to the skin surface

just proximal to the wood slip and is worked steadily to and fro with a gentle sawing movement until it begins to cut. Just as a saw should be allowed to cut its own way through wood, so no undue force should be employed to make the knife cut through the epithelial layers of the skin. It is difficult to explain exactly what is to be done with the wood slip. Sometimes it is necessary to stretch the skin by drawing it down the arm, sometimes to press the edge firmly against the skin, but usually one finds only the very lightest contact is required to render the surface sufficiently taut to allow of easy cutting. As the knife advances so the slip recedes before it, sliding easily over the skin by virtue of its greased edge. Practice on a piece of chamois leather stretched over a board is well worth while, for only practice can develop the proper touch.

Given a sharp knife, a modicum of skill and a reasonable amount of patience, graft-cutting should offer no serious difficulty. To this list of requirements, one should perhaps add a suitable patient, for there certainly are occasional individuals from whose skin it is extremely difficult to cut good grafts. In these it is probably undue thinness of skin which causes the difficulty, for when the skin is very thin and the tension produced by the wood is too great it is a very easy thing to cut through to fat, the skin splitting as though its contents were under tension and anxious to escape.

Mention must be made of various other forms of apparatus which have been devised to aid the skin graft cutter of limited experience. Although the simple knife and wood slip method may be easy to the man who is continually cutting grafts, it does not prove so easy to the occasional skin grafter. The essential point common to all is some means of providing a flat skin surface from which the graft may be cut. In 1921, in association with a colleague, T. Jackson, the writer described a simple skin-stretching device, illustrated in use in figure 2031. This, when made with sufficiently fine and sharp points on its cross-bars, does materially help in graft-cutting. It locks automatically and avoids that "bellying" of the underlying tissues which is often so troublesome. V. P. Blair employs a metal box attached to a suction apparatus and this, when suitably lubricated and drawn along the surface, draws up the skin in a flat line in front of the knife. Neither of these devices provides automatic knife action, and practice with the knife and patience are still required.

Lane-Joynt of Dublin, an expert craftsman in metals, designed an instrument which provides both flat surface and automatic cutting. The principle is that employed in leather splitting, the knife edge following a roller and being adjustable for wide variation in thickness of

graft. This instrument works perfectly so long as the knife is kept sharp and the moving parts are given reasonable care and attention. The sole objections to it are that its cost is high and that the need for insertion of subcutaneous plates makes of graft-cutting a major instead of a minor operation. G. Humby devised an instrument

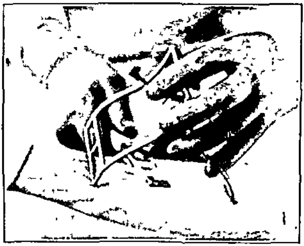

Fig. 2031.—Kilner's skin stretching apparatus in use.

working on somewhat similiar lines but in which the need for subcutaneous plates was avoided by the strapping of a frame to the limb. In this a removable and renewable wafer-steel blade was provided.

He has recently materially simplified his knife, and the latest model, which provides a most efficient means of cutting grafts of varying thickness, is illustrated in figure 2032.

Any instrument which will provide a ready and certain means of graft-cutting must prove a boon to surgeons and patients alike, but as

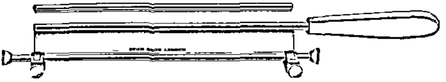

Fig. 2032.—Humby's skin-graft knife.

few surgeons have time and patience to adjust and care for mechanical devices the writer maintains that the simpler the apparatus the more rapidly may the technique be mastered, and the more frequently will the general surgeon be persuaded to employ it in his work.

The graft obtained, it is laid flat on a sheet of gauze moistened with warm saline and is covered by another similar piece of gauze and placed on the table, suitably guarded by a red towel or other means lest it should be lost before it is required. This precaution is necessary,

for, though it barely seems possible, grafts have been seen reaching the main operation area long before they were really required, dragged there unwittingly in swabs or adhering to the sleeve of an assistant or nurse.

The area from which the graft has been cut is now wiped dry and covered with a layer of tulle gras, over which are placed several layers of gauze wrung out of saline. After the application of this dressing, the arm is entirely discarded by the surgeon and handed over to a nurse for bandaging. The precautions already mentioned against shifting of dressings are employed, for otherwise the donor area may easily cause more discomfort than the area grafted.

The recipient area for the graft is now dealt with as an entirely separate procedure. Only in this way is it possible to maintain any degree of asepsis throughout such a two-stage operation. There are, of course, exceptions to this rule, when, for instance, a graft is cut from one part of an arm or leg for transfer to some other part of the same limb. In these cases the whole limb can be prepared at once and there is no need to divide the operation into two such definitely separate procedures.

Whenever the raw surface to be covered possesses *cavity* form, it is advisable to make an accurate mould of it in dental modelling composition (Stent). Such a mould greatly facilitates the application of the graft and ensures contact of the graft at all points on even the most irregular surface. The tablets of Stent are best prepared for use by standing in 1 in 20 carbolic solution until required. This sterilises their outer surfaces which have been subjected to handling. They may, alternatively, be kept sterilised in a jar containing formalin vapour, and are then handled by forceps. When required, they are immersed in boiling water, and when soft are worked up into a smooth mass which is applied to the raw surface and pressed home to fill the whole defect. It has been found of advantage to stretch over the mould a piece of gauze held in such a manner as to imitate the pressure which will be produced by the final dressing. While so held in position the Stent is hardened by dripping over it a stream of iced saline, either from a swab or, more effectively, from a dental chip syringe. When set, the mould is removed and dried. Careful note is made of the impression area and over this the graft is uniformly spread, raw surface outwards. When the surface to be covered is very large, several grafts may be required. These should be so arranged that their edges overlap slightly.

The raw surface is cleared of blood clots and the graft-covered mould is applied. The skin surrounding the defect is wiped with ether

and is smeared with mastisol, as is also the exposed surface of the mould. The margins of the graft or grafts are turned over on to the surrounding skin edges, and the mould is provided with initial fixation by the application of ribbon gauze strips held by the mastisol. The whole area is covered by layers of gauze or wool, and firm pressure is maintained by either a crêpe bandage or elastoplast strapping.

Figure 2033 illustrates the result to be expected from grafts applied on moulds in this manner to the interdigital clefts, while figure 2034

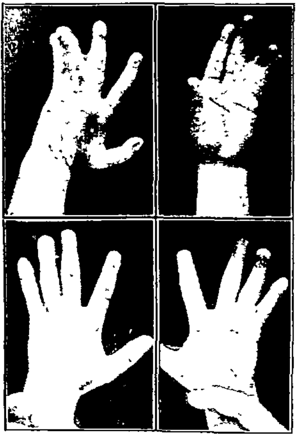

Fig 2033.—A case of congenital syndactyly treated by division of the webs and Thiersch grafting of raw surfaces on Stent moulds.

illustrates the result of grafting the slightly depressed area produced by the excision of fibrosed skin and fascia in a case of Dupuytren's contracture. An area commonly treated in similar fashion is the large depressed raw surface left by excision of an X-ray burn of the back.

I no longer use the Stent mould when the raw area is on a flat surface for I feel that in such situations the mould is liable to shift its position and drag the graft from its bed. Figure 2035 indicates the technique employed in such areas. The graft is spread on the raw

surface, bleeding having been arrested as far as possible by pressure and the application of iced saline, and is marginally sutured by mattress stitches of fine silkworm-gut passed on an eyeless needle. When several grafts are required, their edges are slightly overlapped and may be fixed by occasional mattress stitches passing through the two layers of graft and picking up the raw surface below. The graft is covered by a layer of tulle gras and any underlying blood is expressed by rolling

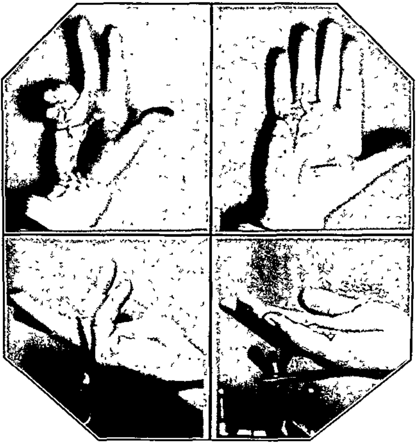

Fig 2034.—A CASE OF DUPUYTREN'S CONTRACTURE TREATED BY FREE EXCISION OF FIBROSED FASCIA AND SKIN. A THIERSCH GRAFT WAS EMPLOYED TO COVER THE RAW SURFACE WHICH REMAINED.

over the area a folded gauze swab. A pressure dressing of cotton wool soaked in saline or flavine and paraffin emulsion is then built up over the graft and the whole dressing is firmly fixed by the means already fully detailed. Careful splinting of a limb so treated must not be overlooked. When the surface to be grafted is a granulating one, it is advisable, as has been mentioned previously, to shave off the granulations with a sharp scalpel or graft knife. This removes a layer of tissue which is likely to be infected and which, in any case, produces discharge capable of preventing correct apposition of the graft. It leaves

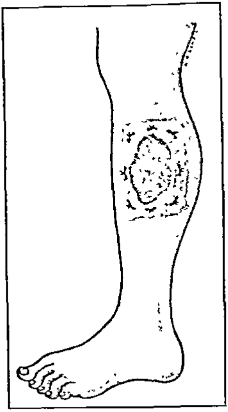

Fig. 2035.—Method of application of a Thiersch graft to a surface defect. Marginal fixation by fine mattress sutures.

a surface with punctate hæmorrhages very like that left in the donor area. Figures 2036 and 2037 illustrate cases treated in this manner.

In the neck region a similar method is employed, though here it is sometimes advisable to use a Stent mould of ample proportions which

Fig. 2036.—Extensive granulating surfaces following severe burn of buttocks and thighs treated by application of large Thiersch grafts. Two small areas where small deep grafts were used are also shown.

will act in the dual capacity of pressure dressing and splint to restrict movement of the parts. Figure 2038 illustrates a result obtained in this manner.

Plaster-of-Paris fixation has a definite place in all plastic work, but it has to be remembered that it is difficult to prepare plaster-casts

Fig 2037.—Long-standing granulating surface following extensive burn treated in several stages by the application of Thiersch grafts. The granulations were removed by shaving before the grafts were applied.

Fig 2038.—*X-ray burn of neck* treated by excision and the immediate application of a Thiersch graft on a Stent mould. It will be noted that the initial depression of the grafted area has entirely disappeared.

beforehand for cases in which contractures are present, and their preparation at the time of operation adds a further long period to what has probably already been a rather prolonged operative procedure.

Post-Operative Care

The donor area is left entirely untouched for at least a week, and

it is usual at that time to be able to peel off the dressing readily and painlessly and to find a completely epithelialised surface already present. The grafted area is also left undisturbed for seven to ten days unless rise of temperature, pain or excessive discharge indicates the need for earlier dressing. The outer dressings are removed down to the mould. The edges of this, which have become glued by inspissated serum and blood, are moistened with peroxide of hydrogen until the mould can be loosened and removed without dragging the newly adherent graft with it. Redundant edges are trimmed away and the surface of the graft is gently dabbed clean of secretions. Any blisters which have formed owing to collections of blood or serum under the graft are opened and evacuated.

Pressure is maintained by a bandage over cotton wool or gauze soaked in flavine and paraffin emulsion. The dressing is changed every two or three days, and a fortnight after operation the grafted area should be ready for gentle grease massage. Liquid paraffin, lanoline cream or cocoa butter may be employed for this purpose. Drying up of the graft should be prevented by keeping its surface slightly greasy. The after-treatment where no mould has been employed is precisely similar, but frequently there is no need to disturb the layer of tulle gras at the first dressing.

The Application of the Thiersch Graft to Special Areas

Thiersch-graft skin is particularly suitable for replacing lost mucous membrane, since mucous membrane itself is difficult to procure in anything like quantity and is, for the most part, placed in rather inaccessible positions. The use of the epidermal graft for this purpose in the eye socket and in the mouth will be taken as examples, and its use on the eyelid will also be described.

Orbital Graft.

The distorted eye socket is prepared by careful excision of all mucous membrane from the inner aspect of the eyelids and from the back wall of the socket. It is better to make a completely skin-lined cavity than to leave mucous membrane remnants producing discharge and spoiling the appearance of an artificial eye. For the removal to be performed efficiently, suction apparatus is almost imperative, for bleeding is usually troublesome and no other means will keep the mucosal surfaces clearly under observation while they are being separated and cut away with scissors. Both upper and lower fornices are deepened, to an extent beyond the normal, by incision and by the removal of any scar tissue encountered in these regions. Hæmostasis

is obtained by picking up and twisting any bleeding vessels, and by means of ice-cold compresses.

Care should be taken in using the suction apparatus lest undue traction is made on orbital fat, for it is desirable that this should be disturbed as little as possible and that a smooth surface should be left to receive the graft.

A Stent mould is made of the over-large cavity thus produced, the eyelids being drawn gently together over it, either by traction sutures or by fine tissue hooks, during the setting process, which is hastened by a trickle of iced saline from a dental chip syringe. Careful attention should be given to filling out the fornices, and the Stent should be moulded into disc-shaped form. Instead of the Stent mould I frequently employ in this situation hollow glass shapes made by Millauro.

It is not altogether essential, but because disappointments have resulted from the too early extrusion of the mould in the after-treatment of these cases, the edges of the eyelids are usually freshened in their middle thirds at this stage in readiness for approximation by suture later.

It is a wise precaution to mark the mould in some convenient manner (as by scratching with a needle) to indicate its front surface and one or other of its extremities, for these moulds are almost symmetrical in shape, and these points are not always easy to recall when the mould has been removed and the graft applied. When set, the mould is removed and dried, and is then draped with the Thiersch graft, raw surface outwards, the junction line of graft edges being arranged to lie in front in line with the palpebral fissure. If the graft is really an epidermal one and is amply large for the job, no difficulty will be experienced in spreading it over the mould. If it is thick and more nearly approaching the Wolfe graft in character (and, therefore, unsuitable for use in this region because it will almost certainly grow hairs), its edges will continually curl back and give endless trouble in spreading. The graft-covered mould is inserted and the freshened portions of the eyelid margins are approximated by a running subcuticular suture. A mild pressure-dressing of gauze or wool is applied over a piece of tulle gras and is retained in position by a crêpe bandage.

Unless pain or tenderness to pressure over the dressing is experienced, the area is left undisturbed for a week, after which any discharge is gently mopped away and the eyelid suture is removed. Gentle irrigation or mopping of the open parts of the palpebral fissure is carried out daily, and the region is kept covered by a pad and bandage or an eye-

shade. The longer the mould can be retained, the more certain is it that a perfectly epithelialised cavity will be found when it is removed. It is for this reason that a glass shape is frequently employed in preference to a Stent mould, since the surface of the latter is liable to become macerated after a time and appears to produce a certain degree of irritation.

The patient leaves hospital soon after the first dressing, and continues to carry out the simple post-operative toilet himself, returning periodically for inspection. Occasionally, inflammatory reaction is encountered, due to retention of discharge behind the mould, or to neglect to keep the open parts of the palpebral fissure draining freely. This complication is not serious and is readily dealt with by free irrigation.

In four to six weeks, when all danger of contraction in the grafted area is past (and this region above all others is especially prone to contraction), the bond of union between the eyelids is divided by a single cut with fine scissors. No anæsthetic, or at most only the injection of a few drops of local anæsthetic solution, is required for this. The mould is removed, and the socket is mopped clear of the epithelial debris arising from original excess of graft, or from desquamated surface layers.

Fig. 2939.—Restoration of eye socket, capable of accommodating artificial eye, by Thiersch graft applied on Stent mould.

At this stage a normally shaped artificial eye of larger-than-normal size is fitted. If such a prosthesis is not immediately available, the mould is replaced and the patient carries out a daily toilet of the socket until he can visit the artificial eye maker. Eyes of gradually decreasing

size are fitted, and finally one of correct shape, size and colour is prepared. It seldom happens that a socket is made too large; very frequently insufficient allowance is made for subsequent contraction. Figure 2039 illustrates a case treated in the manner described.

Symblepharon.

A further modification of this method of grafting has been found useful in cases of symblepharon. It is used as a preliminary measure to corneal grafting or to the fitting of a shell prosthesis in cases where the cornea has been rendered opaque and disfiguring. For this purpose sheet wax, known to dentists as "pink wax," has been found the most suitable material on which to apply the graft.

After freeing of the eyelids from the globe by careful dissection and the removal of scar tissue, a flat disc of this wax is cut, of such proportions that it will fit snugly over the eye and well upwards and downwards into the fornices. This mould is rendered pliable by leaving it for a few seconds in warm water. It is hardened when in position by a stream of cold water delivered by a syringe. In order to avoid undesirable pressure on the cornea, or to relieve it entirely of such pressure in cases where it is undamaged, a suitable circular piece is cut from the mould. The Thiersch graft, already taken, is draped over the mould from behind forwards, covering completely the posterior (ocular) surface and having its edges meeting on the anterior (palpebral) surface along the line occupied by the palpebral fissure. The draped mould is inserted, and the circular area of graft exposed in the central opening is removed so that the cornea is exposed.

The eyelids are now approximated in their central thirds in the manner already described, and a similar dressing is applied. The eye should be examined daily and a careful watch kept for untoward signs or symptoms. After the first few days gentle irrigation may be used to wash away unwanted redundant graft or epithelial debris. The mould should be retained for some 2–3 weeks if practicable. It can readily be removed without separating the lid adhesion, for the wax can be divided by scissors into two pieces which are easily extracted laterally. The eyelids are usually separated, however, at this stage, and free movements of eye and eyelids are encouraged.

Further stages in the treatment of such cases are described in a paper published in the *Trans. Ophth. Soc.*, XLIV, 1929, by Gillies and Kilner.

Ectropion.

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technique employed are well illustrated in figure 2040. The principle involved is that *already stressed as essential in all free skin-grafting, namely*, accurate pressure dressing giving complete apposition between graft and bed. In the eyelid region this desideratum is obtained by stretching the eyelid outwards over the graft-covered mould by means of sutures. The writer is convinced that this, the original method of applying the graft developed by Gillies at the Sidcup Hospital, is superior to any other. for only by this means can efficient over-correction be obtained,

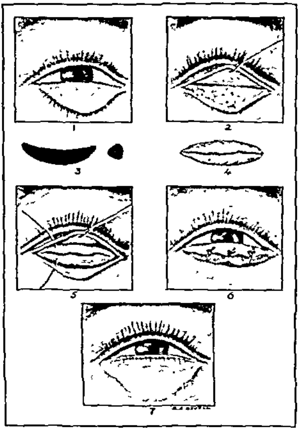

Fig 2040.—Treatment of ectropion by a Thiersch graft applied on a Stent mould.

and allowance thus be made for some degree of subsequent contraction. For a time the newly-grafted surface remains depressed, but this hollowness quickly disappears on light grease massage. Figure 2041 illustrates a case treated by this method.

Early grafting of ectropic eyelids in burn cases is to be most strongly advocated if corneal ulceration and opacity are to be avoided. Further contraction may occur in such cases and ectropion may reappear, but the operation is simple and can readily be repeated.

Intra-buccal Grafting.

In the mouth the Thiersch graft is chiefly useful for the reconstruc-

tion of an obliterated sulcus. In post-War surgery such deformity was extremely common after gunshot fractures of the mandible or maxilla. In civil practice the "buccal inlay," as it has been termed, finds its chief fields of application in restoring contour in the chin region, in the

Fig 2041 —A CASE OF GROSS FACIAL DISFIGUREMENT FOLLOWING ACID BURN. ECTROPION TREATED BY THIERSCH GRAFTS APPLIED ON MOULDS.

premaxillary region in cleft lip and palate deformity, or in the treatment, by the Gillies method, of the "dish-face" deformity so frequently associated with luetic infection.

It is likely to be used increasingly for the re-formation of a buccal sulcus in edentulous cases with excessive absorption of the alveolar bone in which the fitting of a stable denture is otherwise impossible. An example of the use of this method in a case of extreme retrognathism

following trismus is illustrated in figure 2042, while figure 2043 illustrates a case of severe cleft lip and palate deformity treated in a similar manner. In these cases the final contour depends on the shape and size of the dental prosthesis fitted in the skin-lined pocket provided for

Fig 2042.—Retrognathism due to arrested development of symphyseal region of mandible. Deformity corrected by formation of skin lined pocket in front of bone by Thiersch graft applied on mould The pocket accommodates a "prosthetic" denture which restores normal contour.

its reception. In the luetic nose the original mould is later dispensed with in part or altogether. for the final support of the nose bridge is provided by a hinged cartilage graft from the patient's 7th or 8th costal cartilage. A case treated in this manner is illustrated in figure 2044.

For work of this kind in the mouth, dental apparatus is employed in the form of a metal-cap splint carrying an adjustable flange to press

Fig. 2043.—Marked recession of upper lip and nose in a case of cleft lip and palate Contour restored by freeing of lip and nose from maxillæ, Thiersch grafting of raw surfaces on a mould, and the fitting of a denture carrying teeth in correct occlusion with those in mandible

home and retain the Stent mould. In recent years, frequently faced by cases for which expert dental attention could not be obtained or afforded, use has been made of an adaptation and extension of the Ivy method of eyelet-wiring for jaw fractures. This has proved an economical, and in every way satisfactory, method of mould retention and has many

Fig 2044.—Luetic deformity of nose treated primarily by freeing of soft tissues from maxillæ and grafting of raw surfaces by Thiersch graft applied on a mould The final photograph indicates the condition after the provision of intrinsic support for the nose by hinged cartilage graft.

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other applications. Figure 2045 makes this method amply clear when considered with its full legend.

Intra-buccal skin-grafting can be employed with advantage in many general surgical conditions where raw surfaces, leading to disfiguring contraction, are commonly left to close by granulation. An example of such a case is given in figure 2046, where the left maxilla has been

Fig. 2045.—A development of the Ivy loop method of inter dental wiring for the retention of moulds for intra buccal and nasal skin-grafting.

removed for growth. Had a simple half denture been prepared beforehand in this case, provided with clip fixation to the teeth on the right side, and with a projection to the left to support a Stent mould, the whole of the raw surface left by removal of the maxilla could have been readily epithelialised and all disfigurement prevented. Modification of the denture later would have built out the cheek in perfect form, and the necessity for the further operation required would have been avoided.

In the absence of dental apparatus or when teeth are not available

for the alternative method of fixation described above, moulds may be held in place, long enough to ensure satisfactory grafting, by suitably placed silkworm-gut sutures.

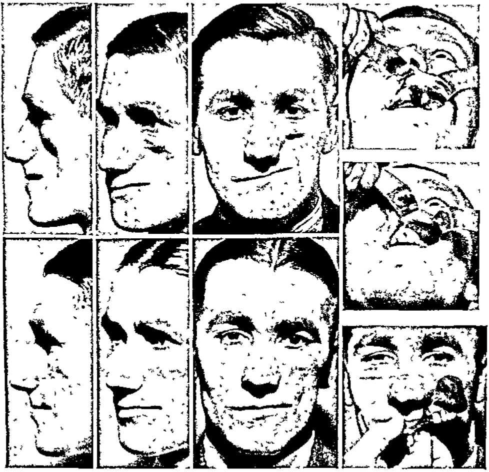

Fig 2046.—A case in which the left maxilla had been removed for growth and the cheek tissues had been allowed to contract The deformity was corrected by the preparation of a Thiersch grafted pocket accommodating an extension from the upper denture

THE WOLFE GRAFT

Although several previous attempts had been made to transplant whole-thickness skin, with varying degrees of success, the credit for the introduction of this form of free skin graft is usually given to Wolfe of Glasgow who, in 1875, described his successful use of the material in the reconstruction of a lower eyelid. In 1896, Krause reported the use of the same type of graft in a large series of cases and described in great detail a technique which differs little from that employed to-day. In view of this work, in which full credit was given to the earlier reports of Wolfe and others, it is not unreasonable that this graft should be named, as it frequently is, the Wolfe-Krause graft. " Full-thickness,"

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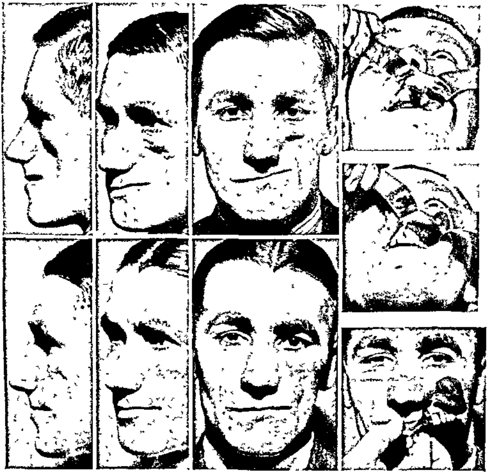

Fig 2046.—A CASE IN WHICH THE LEFT MAXILLA HAD BEEN REMOVED FOR GROWTH AND THE CHEEK TISSUES HAD BEEN ALLOWED TO CONTRACT. THE DEFORMITY WAS CORRECTED BY THE PREPARATION OF A THIERSCH GRAFTED POCKET ACCOMMODATING AN EXTENSION FROM THE UPPER DENTURE.

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"dermo-epidermal" and "dissected" are alternative names for the same material.

The Wolfe graft consists of the full thickness of the skin down to, but not including, subcutaneous fat. It is outlined by a sharp scalpel and freed in much the same manner as that employed in raising skin in the dissecting room. When the outlining incision is being made the skin should not be stretched; once this incision is completed, stretching of the skin by an assistant facilitates the removal of the graft. The graft should be cut to precisely the size and shape of the defect it is to fill and no allowance be made for contraction as was at one time advised. It is essential that lymph spaces should be kept open in as nearly as possible normal state if early establishment of nutrition is to be assured. In order to ensure this, a pattern is made in tinfoil, cellophane, or other convenient material, of the area to be covered, and this, applied to the donor area, is used as a guide for the outlining incisions. With very few exceptions it is impracticable to cut a Wolfe graft (as it is possible and desirable to cut a Thiersch graft) before dealing with the recipient area.

The ulcer or scar is carefully and freely excised, when possible well out into normal surrounding skin and down to healthy subcutaneous tissue. Undermining of the edges is to be avoided for this may lead to hæmatoma formation. The margins of such a wound usually retract spontaneously and sometimes to a surprising extent once they are freed from the scar tissue. It is only after this has occurred that it is possible to judge the size of the graft required, and it is for this reason that the taking of the graft is deferred until this stage. Hæmostasis is of paramount importance and is obtained, without ligatures, by the firm application of gauze sponges wrung out of iced saline solution or by blowing a stream of air on the surface from a hair-drying machine. Where discrete bleeding vessels persist, diathermy coagulation may be employed, but the areas of coagulation should be kept as small as possible.

The pattern is now cut and is marked in any convenient manner to indicate its outer surface and, if of roughly symmetrical shape, at least one of its extremities. It is surprisingly easy to find oneself with a perfectly cut graft which will fill the defect only with its raw surface outwards if these precautions are not taken, and if the pattern is not transferred immediately to the donor area.

In order to maintain strict asepsis in the donor area and more especially when some infection is present in the recipient area, the pattern may be boiled or otherwise sterilised at this stage and the operator's gloves may be changed or washed.

The graft is now cut in the manner described, avoiding all unnecessary trauma by the use of fine tissue hooks in lieu of dissecting forceps. I found the earlier form of tissue hook (Gillies) too thick and large for this purpose and this led me to design the particularly fine hook with detachable handle already illustrated (see fig. 2026). By this means the possession of really sharp hooks can be assured at all times, for the hook portion of the instrument may be discarded for replacement or repair whenever it becomes blunt or otherwise damaged. The graft is spread out on the pattern, correctly orientated and, wrapped in gauze soaked in warm saline, is put on one side while the raw surface left by its removal receives attention. If the raw surface is a small one it may be closed by direct approximation of its edges, after suitable undermining, but this procedure frequently leads to the formation of a keloidal scar. If left to epithelialise spontaneously, healing is delayed for several weeks, the wound is a painful one for dressings, and the resulting scar is often a very disfiguring one. For some time now it has been my practice to cut a Thiersch graft from the neighbouring skin and to apply it with marginal suture fixation and pressure dressing to the raw surface. This ensures a perfectly healed surface in 7–10 days.

The graft is transferred to the recipient area and placed in correct position by reference to the markings on the pattern. Single sutures are placed at four cardinal points, and the edges of the graft are then very carefully stitched to the margins of the defect by a fine silkworm-gut suture on an eyeless (atraumatic) needle applied in continuous end-on (vertical) mattress fashion. The edges are handled very gently with fine dissecting forceps or with the fine tissue hooks already mentioned. All blood is expressed from under the graft, by rolling a folded gauze sponge over it, before the final points of the suture are inserted. A layer of tulle gras is applied and a pressure dressing is built up of cotton wool soaked in either saline or flavine-paraffin emulsion. This dressing is held snugly in position under gentle elastic tension by the application of elastoplast strapping or a crêpe bandage. Ferris-Smith, doing experimental work on such grafts, found that the ideal pressure was 30 mm. mercury, and provided this by incorporating in the dressing a rubber bag (fig. 2047), which could be kept pumped up to this pressure by means of a sphygmomanometer apparatus. Sorbo rubber and sea sponges have been used for the same purpose. In the majority of situations the technique described is sufficient; in others, where application of pressure to an irregular surface is required, the pressure-bag method repays the extra trouble it entails.

Coelst of Brussels has recently described (*Revue de Chirurgie Structive,*

Dec. 1935, 105) *an ingenious method of fixing the grafted area by* means of a " frame " cut in celluloid and attached by fine sutures to the surrounding skin. Over the graft itself he applies either a Stent mould or a sheet of celluloid held in position by a number of sutures passed from side to side of the surrounding frame. When a celluloid covering is employed it is possible to observe the progress of the graft without disturbing the fixation. Coelst stresses the importance of fixation (*contention*) rather than of pressure.

Perforations or snicks in the graft may be employed to provide for escape of blood or serum, but these detract from the cosmetic result

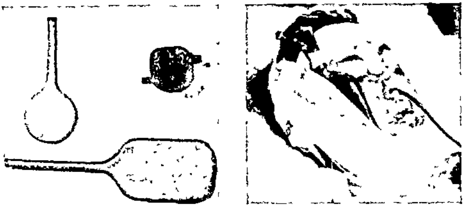

Fig 2047.—Ferris-Smith pressure bags employed to maintain uniform pressure on full-thickness (Wolfe) skin grafts.

and are not necessary when hæmostasis and uniform pressure-dressing can be obtained.

Wolfe *grafts are most successful when the recipient area is backed up* by bone; they are least likely to succeed on soft mobile surfaces. When a limb is under treatment, splinting of adjacent joints should be provided.

It has been shown by Staige Davis and Traut that the Wolfe graft derives its early nutrition from lymph exuding from the raw surface under it. It is for this reason that it is so important that all receptive lymph spaces shall be normally open and not closed as they would be *were the graft cut larger than the defect. Vessels grow in rapidly from* the edges of the defect, and actual bleeding from such a graft has been noted in eighty-four hours. The dressings are left undisturbed for about seven days, when the surface of the graft and the suture line are very gently wiped and the sutures are removed. The dressing is reapplied and pressure is maintained for a further 5–7 days. Bullæ sometimes develop, which should be snipped with fine scissors and treated with a 1 per cent watery picric acid solution. Any small area of

surface necrosis should be treated in similar manner, the object being to maintain a state of dry and localised, rather than of moist and spreading, gangrene. Massage, preferably with some greasy preparation such as cold cream, lanoline cream, or cocoa butter, will do much to keep the graft soft and supple. Without it, the surface epithelium becomes dry and dirty-looking and takes a considerable time to shed itself. Occasionally the whole of a Wolfe graft may be lost owing to the formation of a hæmatoma under it, while frequently small areas of necrosis occur which may rob the result of cosmetic perfection. The marginal scar is usually good, but in some cases it is keloidal and requires suitable radium

Fig 2048.—A pigmented hairy mole treated by excision and immediate application of a Wolfe graft

treatment. While contraction in a Thiersch grafted area is by no means uncommon, little or no contraction occurs in an area successfully grafted with whole-thickness skin. In some individuals a Wolfe graft remains dead white and may stand out as a very obvious patch ; in others, apparently as the result of blood disintegration in its substance, it may take on a peculiar dirty brown tinge which may last for a long time or even be permanent. Expression of blood from the graft before sewing it in position may prevent this discolouration.

It is important to choose, for an exposed, normally hairless region, a donor area free from hairs, and for this reason shaving should play

Fig. 2049.—Extensive scarring of left cheek following lupus treated by excision and Wolfe grafting.

no part in pre-operative preparation. Even when this point has received careful attention trouble may be experienced from the free growth of hairs which were absent or barely visible in the donor area.

Figures 2048–2052 show results of various types of case treated with the Wolfe graft.

Hairy Wolfe Graft.

Free full-thickness grafts may be taken from the scalp or other hair-bearing regions. Such grafts will survive and continue to grow hair, and are of particular value in the restoration of eyebrows in cases

Fig. 2050.—A pigmented hairy mole treated by excision and the immediate application of a Wolfe graft.

Fig 2051.—Defect in lip produced by dog bite treated by immediate application of a Wolfe graft.

of severe facial burns. The technique employed differs in no essential detail from that already described but, where practicable, due attention should be given, both in taking and in planting the graft, to the direction of the hairs. Although ideal in theory, I have had little success with the transplantation of hairy skin from the pubic region to fill defects in the hairy scalp.

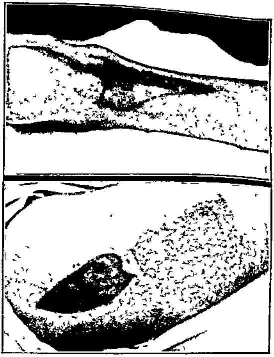

Fig. 2052.—Wolfe graft employed to cover raw surface produced by excision of a chronic ulcer. The lower photograph shows the donor area treated by the application of a Thiersch graft taken from the neighbouring skin area.

THE INTERMEDIATE, SPLIT-SKIN OR THICK RAZOR GRAFT

This graft, used extensively by Blair and Brown, usually cut by the help of the suction box already mentioned, takes a place midway between the Thiersch and Wolfe grafts both as regards certainty of

Fig 2053 —A GRAFT OF INTERMEDIATE THICKNESS (SPLIT-SKIN) USED TO REPLACE THE DISFIGURING SCAR OF CHEEK AND LIP RESULTING FROM TREATMENT BY VARIOUS MEANS OF A CAPILLARY NÆVUS.

" take " and final appearance. Either the Lane-Joynt or the Humby apparatus may be employed for cutting such grafts. Figure 2053 illustrates the result of such a graft on the cheek and upper lip.

SIEVE GRAFT

Douglas has described this graft—a full-thickness graft with numerous circular perforations corresponding to islets of skin left behind on the donor surface. With this, again, the cosmetic result is likely to be far from ideal, while the method of Thiersch grafting the raw surface in the donor area does away with the necessity for assisting healing by leaving behind islands of skin.

BURIED GRAFTS

Braun has revived a method of burying thin Pinch grafts, originally described by Pollock in 1870. McLennan and Keller have separately described *Tunnel* grafting—the introduction of full-thickness skin strips into tunnels made below a granulating surface. Thiersch graft strips have been woven into similar surfaces while epithelial paste, obtained by scraping moist skin with a knife, has been injected below such granulations. The probable explanation of any success with these latter methods is the " natural " pressure dressing and accurate apposi-

tion of graft to bed which the procedures provide. All have their uses in selected cases.

Mention should be made at this point of the results of attempts to graft from one individual to another of the same species (homo-skin-grafting) and from a member of one species to a member of a different species (hetero-skin-grafting).

The evidence is very conflicting but for all practical purposes the dictum of G. C. Padgett given in an Editorial on the subject in *Surgery, Gynecology and Obstetrics* (Dec. 1932) may be accepted as correct: " Isodermic (homo-) skin-grafting is not practicable except possibly from identical twin to identical twin."

In many cases where homo- or hetero-skin-grafting has been attempted, immediate " take " of the graft has been satisfactory but the whole graft has " dissolved " in the course of a few days to a few weeks. Near relationship appears to be of more importance in this connection than blood-grouping.

The use of homo-skin-grafts may be indicated, even although no permanent epithelialisation may be obtained by this means, in small children denuded of large areas of skin by burns, scalds, or other forms of trauma.

On three occasions when Gillies has attempted to transfer a skin flap carrying its own blood supply from one individual to another, complete failure of " take " has resulted. These cases were reported in the Charles H. Mayo Lecture published in *North-Western University Bulletin*, Vol. XXXV, No. 20, Jan. 1935.

CHAPTER III

Other Forms of Free Graft

A. FAT GRAFTS

Free grafts of fat are particularly useful in building up contour where a rounded soft outline is desired. Fat for this purpose may be obtained in ample quantity from the abdominal wall of the average individual; alternatively it may be taken from the thigh. It should be remembered that fat, having a low intrinsic "vitality," is particularly prone to infection, and careful aseptic precautions should, therefore, be exercised in both donor and recipient areas.

An incision is made through skin only. On the abdominal wall it is as well to place this incision away from the region where classical incisions for intra-abdominal operations are made, lest confusion arise later in the patient's history. The edges of the wound are held up by fine tissue hooks and the skin is undermined on a superficial plane sufficiently widely to expose the desired amount of fat. Fat grafts gradually shrink to about two-thirds the volume they possess at the time of insertion, and this must be remembered when the graft is being cut. The wound edges are widely retracted and the graft outlined by a scalpel. The area of fat thus separated is freed from its deep connection by scissors and the graft is placed on one side, wrapped in gauze wrung out of warm saline. All bleeding vessels are picked up and ligatured. Bleeding is usually free and there is danger of hæmatoma formation in the dead space left by the removal of the graft. It is wise, therefore, to insert a small drain in the suture line. An attempt is made to obliterate the space by end-on mattress sutures passed through the skin and picking up the fat surrounding the space. Occasionally these are made to pick up the deep fascia also. The area is temporarily covered by gauze, and at the end of the operation a pressure dressing is built up over this and held in position by elastic adhesive strapping.

Conditions in which fat grafts are found useful are the depressed scar areas sometimes following radical operation on the frontal sinuses, depressed malar and cheek areas where bony replacement has not been carried out early in treatment or where there has been bone loss, and

depressed scars following cervical adenitis where local fat flaps are not available or provide insufficient bulk to fill the defect. They are seldom useful in nose work, for here greater definition and support than they will supply is required. They are occasionally inserted at a later date under the Thiersch graft employed for the correction of ectropion. Theoretically they should be useful in the pectoral region for reconstructing contour, for example, after the removal of the breast. I have never yet had a case where such reconstruction has appeared justifiable, the danger of stirring up further disease having weighed heavily against purely cosmetic considerations, which can readily be met by simple prosthetic means.

The skin of the area to be raised is carefully undermined, access being obtained either by excision of an existing scar or by a fresh incision placed in some inconspicuous position. Bleeding is again usually free and is difficult to control except by pressure or packing, since undermining is of the blind variety and bleeding points cannot be exposed. The fat is cut roughly to the shape of the recipient cavity and is merely packed in, or may be guided into position by sutures passed through the skin at the extremities of the cavity and through the corresponding angles of the graft. These sutures are of the mattress variety and are loosely tied over small gauze rolls. A few points of suture are passed between the margins of the wound, and these, held up by an assistant, bring the skin edges together for the insertion of interrupted skin approximation sutures. The wound edges should be accurately apposed and great care should be taken that no particles of fat separate them. The wound is dressed and the whole area provided with a dressing supplying gentle and uniform pressure. A careful watch for infection or hæmatoma formation should be kept. In evacuating blood or serum, care must be taken that the graft itself is not extruded also. Occasionally a fine drain of twisted silkworm-gut is indicated, but it should be remembered that while providing egress for blood this increases the liability to ingress of infection from the skin surface.

It has been suggested that such grafts do not persist as fat but become organised into fibrous tissue. I have had reason to explore areas where fat grafts have been inserted many years previously and I have encountered fat which to the naked eye differs in no way from normal fat.

The need for over-correction has already been mentioned. It will bear re-stressing: It is a very easy thing to excise a little fat if the over-correction persists when the parts have settled down; it is

troublesome to have to go through the whole process of taking and inserting another fat graft.

The final photograph of the case illustrated in figure 2054 indicates how effectively a free fat graft may be employed to restore the soft contour of the cheek.

When sufficient local material is present, the correction of a depressed scar does not call for the introduction of a free fat graft from a distance. The skin scar is excised and the margins are undermined and retracted to expose the neighbouring deep tissue. Flaps of this tissue sufficient to meet the requirements of the case are fashioned and approximated. In some cases local flaps of this kind are made, but with

Fig. 2054.—Depressed scar treated by excision and the filling of the deep tissue defect by local fat flaps. Since the last photograph was taken the skin scar has become much less obvious.

their bases at the margins of the deep tissue defect and their distal extremities turned over into the depression and fixed by catgut sutures. A depressed scar treated in this manner is illustrated in figure 2054.

B. Bone Grafts

Although bone is occasionally employed in lieu of cartilage for restoration of nasal contour, it is seldom that the plastic surgeon is called upon to use this material except for the repair of defects in the mandible. Such defects were extremely common in early post-War work, bone having been lost as the result of gunshot wounds or following prolonged suppuration and sequestration. In civil practice one is called upon to repair losses due to old osteomyelitis, in cases of un-united fracture, and in cases in which portions of the jaw have been

removed in the treatment of malignant disease. The extent of the loss and the corresponding length of the graft required to make good that loss appear to have no bearing on the success or otherwise of the operation.

It is essential that there shall remain no trace of infection either in the region of the defect or of the external scar, or about the roots of teeth which are likely to be approached during the preparation of the bed for the graft. Teeth should be removed when necessary, and if there is doubt about the scar region the scar should be excised as a preliminary procedure. Firm fixation of fragments—of both when possible, and of the larger fragment when the other is edentulous—is important. When both fragments are edentulous, firm fixation of the graft itself to both fragments is essential, for the graft must act in such cases as the only splint available.

Perforation of the buccal muco-periosteum contra-indicates the introduction of a graft, no matter how carefully the tear is repaired by sutures. No degree of malposition of fragments precludes successful grafting, but severe displacement and extensive scar tissue between the bone ends may necessitate operation in two stages. At the first of these the fragments are freed from the mass of scar tissue and are splinted in good position. It is my practice in such cases always to approach the mandibular fragments from outside, and it is seldom that I have found it impossible to free them and place them in normal position by this route and without opening into the mouth. Occasionally, however, intra-buccal scarring is so extensive that excision of scarred muco-periosteum with plastic rearrangement is required in order *to allow the fragments to be separated and placed in correct position.* In such cases it is wise to wait at least three months before re-operating.

The smaller fragment in fractures near the angle of the mandible, which is frequently edentulous, is usually displaced upwards and rotated inwards so that its inferior border, instead of being roughly horizontal, slopes upwards and forwards. Free subperiosteal freeing of this fragment allows it to be brought down and back into correct position. In long-standing cases this may be impossible without division of the coronoid process to release the fragment from a fibrosed and contracted temporal muscle. I have never noted any disability following this procedure nor following the free separation of masseter and pterygoid muscles. These muscles undoubtedly establish fresh connections and take up their normal functions when the jaw is released from splints. The edentulous posterior fragment is maintained in good position by the bone graft itself.

The larger tooth-carrying fragment is always fixed in occlusion, beforehand if possible, by metal-cap splints provided with some bolting mechanism holding the lower teeth to the corresponding ones in the upper jaw. Where expert dental collaboration is not available, simple inter-dental wiring provides satisfactory fixation. The splint illustrated (fig. 2055) was prepared by Mr. A. L. Fraser and is the type

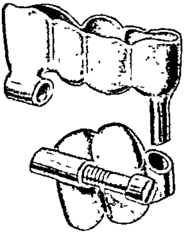

Fig 2055.—Metal-cap splint with screw employed in bone graft operations on the mandible.

used at the Ministry of Pensions Hospital, Roehampton. Such an apparatus makes for clean and firm fixation and allows of easy separation of the jaws at intervals for an estimate to be made of the firmness of union.

Technique of Bone Graft Operation

The jaw fragments are exposed through an incision planned to leave a scar line just below the line of the restored mandible. When a scar is already present, this is excised and elongated, if need be, to obtain free access to the bone ends. Skin flaps are freed for a short distance above and below, and an incision is then made through the deep tissues straight down to bone. The internal and external surfaces of the bone are cleared by a rougine. Any irregular spicules of bone are divided at their bases and carefully twisted out of their adherent deep tissues. Attempts to work completely round such projections by rougines or elevators are fraught with grave risk of opening into the mouth cavity. The ends of the fragments are trimmed with bone-cutting forceps. The posterior fragment, when unfixed by a splint, is steadied by means of a large pair of Kocher forceps clamped on it near the angle. The fragment is freed and placed in good position as already described. A saw cut is made on its outer surface about 2·5 cms. from its extremity and parallel to its cut end. This saw cut is usually made with a key-hole or nasal saw, but an electrically-driven circular saw of small dimensions (the crown

saw used by dentists) facilitates the work. The saw cut goes through the outer table only. The outer surface of bone between the freshened extremity and this saw cut is removed by driving a thin osteotome backwards from the cut extremity. Two holes are drilled through the remaining inner table, one above the other, at a distance of about 1·0 cm. Fine silver, stainless steel or phosphor-bronze wire is threaded through these holes, the loop being left on the deep surface of the bone and the ends coming out on the freshened surface. These ends are clamped and wrapped in gauze to prevent contact with skin edges.

The anterior fragment is prepared in precisely similar manner.

Difficulty may be encountered in threading back the wire suture from the deep to the superficial aspect of the bone. A tubular guide may be used for this purpose, or a needle, passed eye first from without inwards, may be threaded with the wire, which is then easily drawn through. A model is now made in sheet lead of the graft which will be required to bridge the gap and overlap the freshened surfaces of the fragments, and on this are marked the positions of the points of egress of the wire suture. Blood-vessels are ligatured and the wound is packed with a gauze swab.

Taking the Graft.

The graft is taken from the crest and outer surface of the ilium on the side of the defect, and the illustration (fig. 2056) indicates the piece of bone to be removed. The necessary cuts are usually made with thin osteotomes, though they may be made still more readily by means of a motor-driven circular saw. The removal of this portion of the ilium causes no disability or disfigurement and it interferes very little indeed with muscular attachments. The anterior superior spine is left undisturbed. Periosteum is taken with the bone. The knife is passed under the ligamentous layer on the crest and this is turned inwards as a flap. The glutei muscles are separated from the outer surface of the bone and retracted. As a rule, only one small vessel requires ligature.

The lead pattern is laid on the outer surface of the bone and its anterior, posterior, and inferior margins are outlined by cuts with a sharp osteotome. These are carried half-way through the thickness of the bone. The osteotome is then driven downwards from the mid-line of the crest, and the separation of the graft is thus completed. The separated piece of bone, grasped in Lane's bone-holding forceps, is wrapped in a warm sterile towel and transferred to a separate table for later modelling. The wound is closed in two layers—the first of catgut sutures approximating the cut gluteal fascia to the fascial flap turned up from the crest. It has been found that the extended position of the

hip gives greatest relaxation for this to be carried out, but occasionally it is necessary to vary the position of the leg during the suturing process. *The second layer consists of skin suture of ordinary type.* A rubber-dam drain is inserted at the posterior angle of the wound for forty-eight hours. The graft is trimmed of any pieces of muscle which remain attached to its outer surface, and is then cut and drilled in corres-

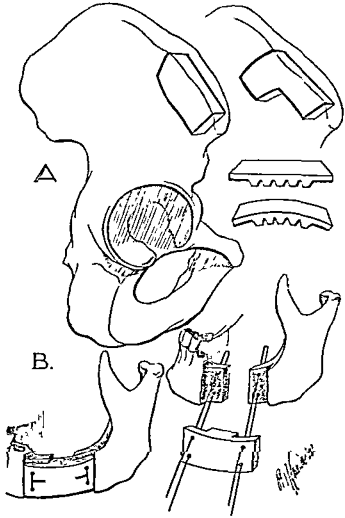

Fig. 2056.—The technique of mandibular bone-grafting. Straight, curved and angled grafts are illustrated above. *Below*, freshening of fragments and method of fixing the shaped graft by wire mattress sutures.

pondence with the fragments to which it is to be morticed. The necessary transverse cuts are made with a small saw and the cancellous bone is removed either by the same instrument or by bone-cutting forceps. The whole procedure can be done in a few minutes. The graft is held by the Lane forceps throughout and is protected carefully from contact with the skin whilst it is being placed in position in the mandibular wound.

This technique has been varied a little from time to time by drilling

the graft before removing it from the ilium, but no serious advantage is gained by this manœuvre and there is some danger of carrying the drill too deeply in one's effort to make a clean hole.

The graft is threaded on the ends of the wires, guided into position, and held there while the wire loops are tightened by twisting. The twisted ends are cut short and gently pressed into the outer surface of the graft. The deep tissue flaps are approximated over the graft by catgut sutures and the skin wound is closed by interrupted stitches of fine silkworm-gut, a small drain being inserted to guard against a blood collection which in this situation is so liable to become infected.

In cases where the angle is missing and a reasonable fragment of ascending ramus can be found and freshened, an angled graft has sometimes been cut as indicated in figure 2056. In cases where extensive portions of bone are missing from the front of the jaw, the graft may be curved to suit the chin contour by making saw cuts on its cancellous surface, similar to those made by Albee in his spine grafts, or by the excision of wedges from this surface. Multiple small wedges weaken the graft much less than fewer but more extensive ones.

I have employed a curved graft of this type 12 cms. long (i.e. about $4\frac{1}{2}$ inches) to bridge a gap extending from molar to molar region. In this case the soft tissues of the chin region had been reconstructed by a double pedicled forehead flap brought into position over marginal in-turned flaps which had restored the lining of the defect (see fig. 2065). At a later date the hair-bearing in-turned flap was removed and a new gingival sulcus was prepared by Thiersch grafting on a mould placed in front of the bone graft. This allowed a lower denture to be fitted which not only improved the contour of the chin but restored masticatory function.

T. J. D. Lane of Dublin has devised an instrument which greatly facilitates the preparation of such long curved grafts. It consists of two springy pieces of steel, between which the bone graft is placed, and which can be clamped together. Along the edge of one of these are a number of little raised ridges which prevent the graft from slipping. Before bending, cross-cuts, as already described, are made on the cancellous surface of the graft. By slowly increasing pressure made with the fingers, the graft can usually be curved or bent to the degree necessary without causing a break. If much bending or angulation is required, and more particularly in older patients, a break may and often does occur even when this instrument is employed. Such breaks can, however, be only subperiosteal in character and do not affect the final consolidation of the graft.

After-Treatment.

Drains are removed from lip and jaw wounds in forty-eight hours. Skin sutures are removed, some on the fifth and the remainder on the seventh day. Apart from ordinary oral hygiene no further after-treatment is required. Where intra-oral splinting has been impracticable every effort is made, by external bandaging, to prevent movements of the jaw. In six to eight weeks union is usually sound, and free active movements may be allowed. X-ray examination at intervals after the operation helps in estimating the progress of bony union and

Fig. 2057.—Old osteomyelitis of mandible with pathological fracture and non-union on left side. The case was treated by bone graft from ilium, and later a new gingival sulcus was constructed by a Thiersch graft applied on a mould. Both functional and cosmetic results were satisfactory.

the maintenance of good position, but clinical examination is the more certain criterion in deciding when splints may be discarded.

In most cases of mandibular bone graft a subsequent "buccal inlay" is required to reconstruct the gingival sulcus and so make it possible for the dentist to fit a denture. It is wise to wait for at least six months after the bone graft operation before carrying out this procedure in order to avoid risk of infection at the sites of wiring. Only in exceptional cases has it been necessary to remove the wire sutures at a later date.

Figure 2057 illustrates the result obtained in a case of old osteo-

myelitis with pathological fracture and non-union on the left side of the mandible. Figure 2058 is a skiagram showing the graft in position in a case in which extensive loss of bone followed a pit explosion injury.

Fig 2058.—LEFT SKIAGRAM SHOWS LOSS OF BONE ON RIGHT SIDE OF MANDIBLE FOLLOWING PIT EXPLOSION INJURY. RIGHT SKIAGRAM SHOWS RESULT OBTAINED BY ILIAC BONE GRAFT.

C. FASCIA LATA GRAFTS

In the absence of infection, fascia lata behaves excellently as a free graft. It may be used, as material having a rather firmer consistency than fat, for contour building, or it may be taken together with overlying fat for this purpose. It is used occasionally for supporting the upper eyelid, as in operations for ptosis. I, personally, reserve it almost entirely for facial paralysis cases. In such cases, even though there may still be some hope that recovery of nerve function may occur, a fascia lata sling to the angle of the mouth is well worth while. It supports the paralysed muscles and prevents damage to them by stretching during the recovery stage, and is infinitely to be preferred to any external splinting.

When paralysis is established—the face drooping and lacking any natural movement or expression, food accumulating in the lower buccal sulcus, and the unparalysed muscles of the opposite side drawing the mouth over in disfiguring fashion whenever movement is attempted—fascia lata slings to the upper lip, the lower lip, and the angle of the mouth give both cosmetic and functional improvement.

Figure 2059 indicates clearly the technique employed. Short incisions are made on the unparalysed side of the philtrum in the upper lip and parallel with the lip margin at a corresponding point in the lower lip. A small curved incision is made just outside the angle of the mouth on the paralysed side. The edges of these incisions are undermined for a short distance in order to expose the underlying muscle-fibres.

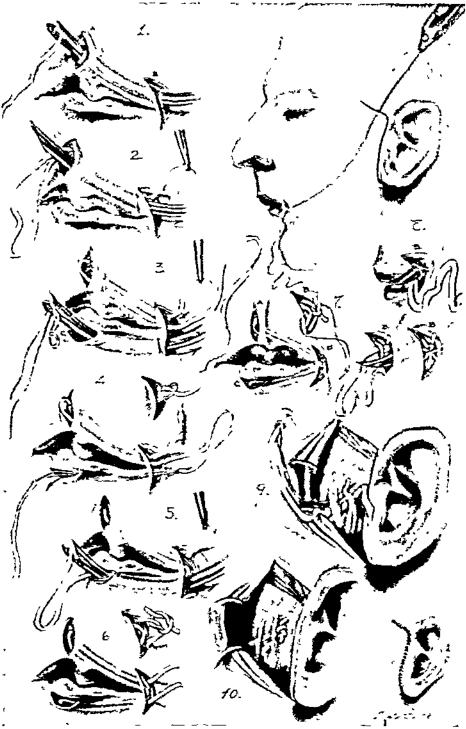

Fig. 2059.—The technique of the fascia lata sling operation for facial paralysis.

A special trocar needle (Blair-Smith) is inserted at *B* and passed in the deep tissues of the upper lip to emerge at *A*. A fascia lata strip is drawn back to *B* and its end is held in pressure forceps. The needle is again inserted at *B* and passed more superficially and nearer to the lip margin, to emerge again at *A*. The other end of the fascia strip is now drawn back to *B*, ready for use on the lower lip. It is essential that the fascia loop so formed should have a firm hold of the unparalysed muscle exposed in the lip incision *A*.

The needle is now passed from *B* in a superficial plane and near to the lower lip margin, and emerges at *C*. It draws back to *B* a loop of silkworm-gut. This loop is knotted over the free end of the fascia strip and serves to draw it through to *C*. The needle is again passed, this time on a deeper plane and picking up unparalysed muscle before emerging from the lip incision. The end of the fascia strip is drawn back to *B*. A strand of silkworm-gut is passed under the fascia loop at *B* to act as a guide later in the operation. The free ends of the strip are knotted and drawn taut enough to contract slightly the paralysed half of the mouth. The knot is reinforced by fine silk sutures which should pick up only a few fibres of the strand. The incisions in the lips are then closed by fine sutures.

An incision is now made precisely as for cosmetic face-lifting in the temporal and pre-auricular regions, and the skin of the cheek is undermined superficially sufficiently to expose an area of the parotid fascia below the zygoma. The trocar needle is passed subcutaneously from the depths of this wound to emerge in the incision at the angle of the mouth where, following the silkworm-gut guide, it passes through the double loop of fascia controlling the lips. One end of a new strip of fascia is caught up in the needle and drawn back to the temporal region. The needle is passed a short distance from its previous track in the cheek and emerges again at *B* to draw back the other end of the cheek loop. This loop may with advantage be made to pick up in its course deep tissues near the angle of the mouth. The wound at *B* is then sutured.

The free ends of the cheek loop are now threaded on J. T. D. Lane's fascia needles and woven into the parotid fascia. They are drawn sufficiently tight to over-correct the position of the angle of the mouth and are then knotted. The knot is reinforced by one or two fine silk sutures. The skin flap is drawn upwards and backwards and the overlap is removed (see fig. 2114). Interrupted sutures close this wound.

As a rule, it is necessary to carry the skin incision around the ear lobule attachment and backwards in the retro-auricular groove for a

has been carried out in conjunction with that described for the support of the mouth and cheek.

It has not been thought necessary to describe the technique employed in obtaining fascia strips from the thigh. An endless variety of fascia "strippers" is available. I habitually use that devised by Lane of Dublin—the Meath Hospital fasciatome.

D. CARTILAGE GRAFTS

Cartilage has proved a most useful material for contour restoration, particularly in the nose where support rather than the mere filling in of a contour defect is required. It may be obtained in ample quantity from the region of the costal margin, and it can be readily cut to any desired size and shape. Cartilage is one of the few body materials which can be transplanted successfully from one individual to another. It need hardly be mentioned that no such transfer should be attempted without careful preliminary blood tests, lest latent disease be transferred from donor to recipient.

No detailed description need be given of the operation for removal of the cartilage. That portion of the 7th right costal cartilage ascending to the sternum is the material usually removed, and it is approached through a rectus-splitting incision (see fig. 2084). The free extremity of the 8th costal cartilage is almost always exposed in the wound, and a varying length of this is commonly removed to be kept as spare material. An oblique incision following the costal margin provides a more difficult approach but gives a less obvious scar line, and is sometimes chosen for this reason or when only a small piece of cartilage is required.

When larger masses of cartilage are required, the area of fusion of cartilages is readily exposed. When removing such larger pieces in this region care must be taken to prevent damage to the underlying pleura. At the end of the operation all spare cartilage likely to be of further use in case of infection and extrusion of the first graft, or in case further building up is required later on, is buried subcutaneously in the abdominal wall. From this situation it is readily removed under local anæsthesia and with a minimum of disturbance to the patient.

After removal of cartilage from the ribs the patient experiences considerable discomfort, particularly on moving, for 24–48 hours. Much can be done to minimise this by careful strapping of the wound with elastic adhesive strapping, much in the same way as fractured ribs are immobilised. As already mentioned, rib cartilage finds its chief field of usefulness in building forward and supporting the depressed bridge of the nose. It is employed for the same purpose in

reconstructive rhinoplasty to support the soft parts which have been restored by forehead flap or other means. Cartilage has one bad fault, namely, its tendency to curve, and this has led many workers to abandon it in favour of bone. Much can be done to prevent this late distortion by carefully removing perichondrium, and in some cases, when a two-stage operation is essential, the cartilage may be taken before it is required, denuded of perichondrium, and buried in the abdominal wall. When required, any curving which has occurred is corrected in the shaping of the graft.

The larger masses of cartilage mentioned are found useful in building up malar contour where there has been loss of bone, and for filling depressions in the forehead or defects in the skull. When only small contour defects are to be treated, sufficient cartilage for the pur pose may be obtained either from the upper part of the alar cartilages of the nose, the removal usually improving the shape of the nose tip, or from the ear. Cartilage from this latter source is particularly suitable for supporting the drooping lower eyelid in facial paralysis.

The technique of the nasal cartilage graft operation is described later (see fig. 2084).

CHAPTER IV

Flaps

Advancement or Sliding Flaps

Although not usually visualised as such, the areas of skin which are undermined from the margins of a defect and advanced and approximated to cover it, constitute flaps which fall into this category. All reasonably small defects, such as those produced by the excision of hairy or pigmented moles, are closed in this manner. The skin incisions extend beyond the mole in elliptical form in order to facilitate closure without protrusion or dimpling at the extremities of the suture line. The procedure may be modified to meet the requirements of more extensive skin blemishes. Only a part of the undesired area is removed at the first stage; the wound margins are undermined and approximated, and a scar line is left within the confines of the area itself. After a delay of some months, during which the surrounding skin is massaged, the remainder of the area is excised in elliptical fashion, and it is usually found that the undermined skin edges can then be approximated without undue tension. In some situations the complete excision of quite large skin areas can be achieved in several stages of this kind with the obvious advantage of leaving a single linear scar line. The excisions are carefully planned so that the final scar may be as far as possible in a natural skin fold.

Where the skin available is limited, as on the leg, yet it is essential that a skin defect shall be covered by healthy full-thickness skin bearing some fat, lateral relaxation incisions may be made. These allow of easy approximation of the sliding flaps without tension. The gaps produced at the sites of the relaxation incisions may be covered immediately by Thiersch graft or left to epithelialise spontaneously.

Rotation Flaps

These were first described and extensively employed by Esser. A large area of skin adjoining a defect is partly or completely undermined. Carefully planned incisions allow this flap, while retaining a broad base, to rotate into position over the defect. Closure of th incision by interrupted sutures allows of even distrib of tensio Figure 2061 illustrates a case in which the skin of the

Fig. 2061.—Record of a case in which a large rotation flap was employed to cover the defect in the infra-orbital region produced by the excision of a capillary nævus.

Fig. 2062.—Record of a case in which a flap transposed from below the mandibular margin to a vertical position on the cheek, was used to cover the defect produced by excision of an *epitheliomatous ulcer in an old lupus scar*

clockwise to fill a triangular defect in the infra-orbital region produced by the excision of a very disfiguring nævus. It will be seen that the secondary scarring necessarily produced has been arranged to fall in situations where it is barely visible.

Transposed Flaps

Into this category fall those flaps, deliberately formed from the adjacent skin, whose long axis is made in a direction roughly at right angles to the long axis of a defect. Many such flaps are employed for the immediate closure of defects about the mouth and cheek.

Figure 2062 illustrates a case in which such a flap was cut from the skin immediately below the mandibular margin and swung up to cover the raw surface produced by the excision of an epitheliomatous area which had developed in an old variously-treated patch of lupus.

Figure 2063 illustrates a case in which a nasal defect, produced by the excision of a rodent ulcer which had resisted treatment by radium,

Fig. 2063.—A case illustrating the use of a transposed flap from the naso-labial fold for the repair of a defect produced by the excision of a rodent ulcer which had resisted treatment by radium. The base of the flap was above, and its lower (distal) portion was in turned to provide lining for the defect.

was repaired by a long narrow flap from the naso-labial cheek fold. The base of the flap was above, and its distal portion was folded upwards to provide lining for the defect.

Triangular flaps of this type are commonly shifted from above to below the angle of the mouth. When obtained from the naso-labial fold region, the resulting scar is seldom noticeable.

Flaps from the same region may be cut of full thickness, carrying skin, muscle and mucosa, and these supply particularly valuable reconstructive material (fig. 2064).

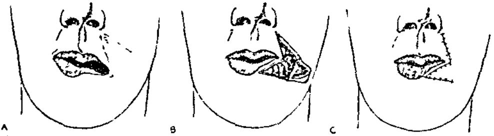

FIG. 2064.—FULL-THICKNESS TRANSPOSED FLAP FROM ABOVE TO BELOW THE ANGLE OF THE MOUTH.

Bridge or Pedicled Flaps

The most commonly used flap of this type is that cut from the forehead in nasal reconstruction by the so-called Indian method (see fig. 2072). Such a flap has a pedicle which overlaps the skin between donor and recipient areas and which is retained only so long as it is necessary to maintain the nutrition of the flap while it is establishing its own connections with the recipient area. In some situations, in order to diminish exposed raw surface, the pedicle may be tubed, i.e., its margins may be approximated by sutures. The pedicle of such a flap may be safely divided and returned in 2–3 weeks according to the vascularity of the area to which the flap is attached and according to the extent of this attachment.

A forehead flap may have its pedicle based on the superficial temporal vessels of one side, or the whole of the skin of the forehead may be swung down like a bucket handle on two pedicles of this type. The former is useful when the nose and part of the cheek have to be reconstructed, the latter is particularly useful for reconstruction of the chin and lower lip regions.

The diagrams in figure 2065 were drawn from an actual case in which the chin region was built up by this means. At a later stage of treatment a curved bone graft, introduced between lining and covering skin, restored the continuity of the mandible, while still later the hairy in-turned skin was removed and replaced by Thiersch graft. At the same operation a new gingival sulcus was constructed in front of the

ingenious and most satisfactory means of transporting skin from a distance. Designing flaps of precisely similar type, independently and in the same year, he immediately found many new applications for the principle involved and rapidly extended their field of usefulness in all branches of reconstructive work.

By means of such flaps large areas of skin may be transported with safety from the chest or abdominal wall to situations as far distant as

Fig 2067.—A tubed pedicle flap prepared on the chest wall and transferred in stages to reconstruct an extensive cheek defect.

the sole of the foot or the top of the head. An intermediate attachment to the wrist is the most suitable method of transfer (where direct transfer is impossible), but in selected cases the flap may be moved in several stages in " caterpillar " fashion.

The details of preparation and transfer are well illustrated in figure 2066, while figures 2067 and 2068 illustrate typical results obtained by direct transfer of tubed pedicle flaps from chest to face.

It is unwise to prepare a tubed pedicled flap materially longer than

6 inches or narrower than $2\frac{1}{2}$ inches. Greater length may be obtained by extending the flap after a short delay. The defect produced by removal of such an area of skin can be closed by approximation after undermining of wound edges.

It is wise to drain both the abdominal (or chest) wound and the tube itself for forty-eight hours.

If a wider flap is required, the abdominal or chest wound is covered immediately by Thiersch grafts, and in this way one of the greatest

Fig. 2068.—A tubed pedicle flap prepared on the chest wall and transferred in stages to fill the defect produced by the excision of an angioma of the cheek which had resisted prolonged treatment by other means.

advantages of the flap is maintained, namely, the leaving of no raw surface for painful dressing or for infection.

It should be stressed that the skin tube itself *is* the flap; it *is not* the pedicle on which a flap of skin extending beyond one or other attached end is to be transferred. Any attempt to carry skin in the latter manner is fraught with extreme risk of necrosis unless the area of skin beyond the tube is first delayed in the manner already described.

Special applications of the tubed pedicle flap for nose reconstruction are illustrated in figures 2076 and 2077.

CHAPTER V

Types of Repair

Some *general remarks on this subject would appear to be not out of* place at this point.

In planning reconstructive work about the nose and mouth, more particularly at the time of a destructive operation called for by the presence of *a malignant growth, a careful decision must be made as to* the advisability of carrying out primary or secondary repair. The dangers of the former may be briefly tabulated as follows:

(1) The destructive operation is likely to be carried out in less radical and satisfactory manner if closure of the defect he is producing is constantly in the thoughts of the operator.

(2) The shifting of local flaps to fill in the defect opens up new tissue to infection from the cavity involved, and is likely to increase the danger of spread of malignant disease.

(3) The available skin bordering on the defect is frequently unsuitable plastic material. It may be scarred or may have been partly devitalised by X-ray or radium treatment of the malignant growth or other disease.

(4) Except when the defect produced is small, local flaps are seldom sufficient to make a really complete replacement of removed parts, and the reconstruction is likely to be a disappointing one from the cosmetic point of view.

(5) It is seldom possible to be certain of the complete removal of a malignant growth. Primary repair gives no opportunity of judging this and may [illegible]ome extremely complicated by recurrences *which, being* [illegible] *[illegible]eedingly difficult to treat.*

Primary repair may be [illegible] [illegible]nce, however, from the psycholog[illegible] [illegible] of view [illegible]l strain placed on a patient w[illegible] [illegible]stance, [illegible] weeks dribbling saliva from a la[illegible] into th[illegible] [illegible]ive due consideration. In this c[illegible] [illegible]y be [illegible] expended on the [illegible] patient's comfort.

The advantages of secondary repair may be similarly tabulated:

(1) The destructive operation may be carried out in really radical manner, the surgeon being unhampered by thoughts of the reparative procedure.
(2) Sound healing of the borders of the defect gives a greater field of plastic material, and leaves marginal skin flaps available for turning in to reconstruct the lining of the defect.
(3) A period of observation for local recurrences is given. Such are unhidden and may receive appropriate treatment immediately.
(4) Time is given to plan deliberately and carefully a replacement by ample healthy material brought from a distance where any secondary deformity is of no moment or is completely hidden.

Secondary repair, however, usually necessitates a series of operations extending over a considerable period of time. In spite of this disadvantage my inclination is always towards this type of repair, for I have encountered no more distressing cases than those in which patients have been called upon to submit to a second destructive operation. Final repair in such circumstances becomes a very complicated procedure.

In all such cases as those under discussion it would seem best to arrange for close collaboration between the general surgeon and the plastic surgeon. The latter will encourage the former to be radical in his removal and will guide him in how to treat the margins of the defect so as to facilitate repair at a later date. In many cases he will be able to carry out the first stage of the reconstructive procedure by preparing a tubed pedicle flap on the chest or abdominal wall at the same operation.

Because of my firm opinions on this subject I do not propose to include descriptions of primary reparative procedures. Countless skin and full-thickness flaps falling into the various categories already mentioned have been designed, and excellent descriptions of these will be found in *Les Autoplasties*, published in 1907 by Nelaton and Ombrédanne.

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Primary repair may be of great importance, however, from the psychological point of view, and the physical strain placed on a patient who, for instance, must go about for weeks dribbling saliva from a large opening into the mouth, should receive due consideration. In this connection it may be mentioned that a little ingenuity expended on the dressing of such cases may add materially to the patient's comfort.

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CHAPTER VI

Operations on the Nose

A. Reconstructive Rhinoplasty

The whole history of plastic surgery is intimately linked up with this subject. It would serve no useful purpose, however, to discuss the endless variety of methods which have been advocated or practised and I shall describe only the routine procedure which I employ. This is based on the so-called Indian method, to the development of which Keegan and Smith contributed so much of the pioneer work. It will be readily seen that this can be modified to meet the requirements of almost any defect in this region. It is quite true that very satisfactory prosthetic appliances, fashioned in metal or pliable material, can be made to hide defects in the external nose. These may be attached to spectacle frames or fixed by glue so that the line of junction between artificial and real is barely noticeable. They are, however, expensive in first cost and require renewal or renovation at frequent intervals, while for the ordinary working man who must submit them to the effects of dirt and weather they are, in my opinion, impracticable. Even at their best they cannot supply that sense of security which is given by a nose reconstructed in " flesh and blood," a feature which, even if not perfect in every detail, becomes essentially a part of its possessor. When it is realised that a few weeks' hospital treatment can transform a hideous creature, shunned by everyone, hiding his disfigurement by bandage or ill-fitting artificial piece, into a normal-looking individual, eliciting, at the most, interested observation; and when it is realised that a little further operative work, carried out some two to three months later, can add to the nose shapeliness and character and obliterate those minor defects in restoration which elicited even such observation, it must be conceded that there is every reason for preferring reconstruction to the camouflage of the artificial piece.

The chief essential, still sometimes overlooked, in nose reconstruction is the supply of adequate lining material. In post-War cases this could usually be obtained in sufficient quantity by turning in flaps based on the margins of the defect; but in the majority of cases

encountered in civil practice, the skin in the neighbourhood of the defect is fibrosed or atrophic as the result either of the original disease (e.g., lupus or rodent ulcer) or of its treatment. Even should such material survive, it is liable to undergo considerable shrinkage, either because of its initial poverty of nutrition or on account of its necessary rotation through almost 180 degrees.

For many years now it has been my practice to rely more and more on the forehead flap for the provision of both covering and lining. This plan is by no means a new one, for it was described by Gandolfi and Bertani in 1845 and was rediscovered thirteen years later (1858) by Pétrali, who relates how he came upon it by chance whilst idly folding a mulberry leaf in his fingers. As the result of attempts to estimate beforehand, by means of patterns and models, the quantity of skin required to supply sufficient lining material and at the same time provide something adequate for the columella and "septum," I have come to in-fold the flap to a greater extent than is usual. The shape and size of flap required in any particular case can be planned beforehand by patterns cut in chamois leather or in thin sheet lead. The former material simulates closely the skin, while the latter has the advantage of retaining the form into which it is moulded. Either can be boiled and used during the actual operation.

It may be noted here that a certain amount of hair on the in-turned portion of the flap is not seriously troublesome; this allows one to carry the forehead incision outlining the flap to a reasonable extent into the downy skin of the anterior temporal region.

Preparation of Defect.

The nose stump is prepared (fig. 2069) by incisions placed near the margin of the defect in such a manner as to leave a narrow frill of skin on the inner (lining) side to hold the sutures which will unite it later to the in-turned edges of the forehead flap. These incisions are carried down the lateral margins of the defect to points on the upper lip chosen for the basal attachments of the new alæ. The skin of the cheek is undermined slightly to facilitate later suture to the flap. The anterior border of the septal remains is incised, and the mucosa is reflected for a short distance on each side. This septal incision is carried down on to the lip where an area is prepared, by removal of a small piece of skin or scar, for the attachment of the columella. Any scarred skin covering the upper part of the nose remains is dissected off and discarded.

When no septal partition is present it is an advantage to retain and turn down a narrow flap from above, and to suture its distal border to a

small flap turned upwards from the centre of the lip (fig. 2070). This flap is in no way comparable to the hooded lining flap frequently employed in post-War injuries. It does not form any material part of the lining of the new nose, but makes a useful backing for the new "septum" and gives something reasonably fixed to which may be sewn the central part of the in-turned portion of the forehead flap.

The aim of this preparation of the nose defect is, in all cases, to

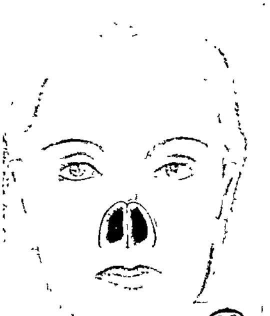

Fig 2069.—Preparation of nose stump for reception of forehead flap. The area of skin or scar usually removed from the upper part of the nose is not indicated.

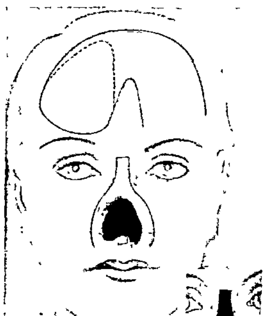

Fig 2070.—Preparation of nose stump when no septal partition remains. Lines of incision for raising flap and pedicle are shown on forehead.

produce two separate airways bounded by material capable of holding sutures. These apertures lie in the coronal plane or slope forwards from that plane above, according to the greater or less degree of nose destruction. When they lie flush with the rest of the face, the reconstruction calls for the maximum of in-turning of the flap, while this requirement diminishes in proportion as their slope forwards is more marked. When the margins of the nose defect are unhealthy, e.g., the site of ulceration or keratosis, all diseased material is excised and the remaining edges are split for a short distance to separate their lining and covering

constituents. It will thus be seen that a reconstruction operation *may* follow immediately upon a destructive one, for a healthy-margined defect may be produced by wide removal of such lesions as rodent ulcer. It is the part of wisdom, however, in such cases to separate these operative procedures, sewing mucous membrane to skin around the defect at the close of the destructive procedure and waiting for a

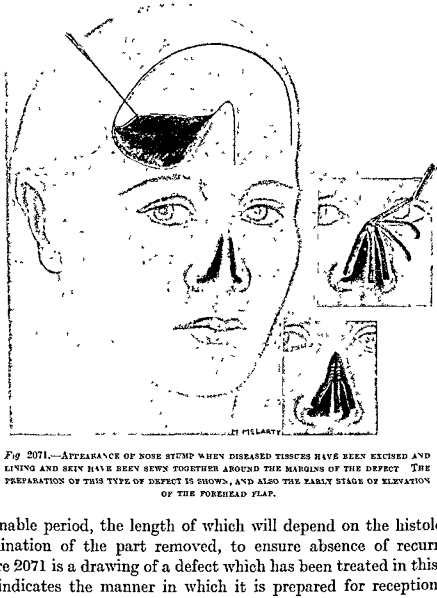

Fig 2071.—APPEARANCE OF NOSE STUMP WHEN DISEASED TISSUES HAVE BEEN EXCISED AND LINING AND SKIN HAVE BEEN SEWN TOGETHER AROUND THE MARGINS OF THE DEFECT THE PREPARATION OF THIS TYPE OF DEFECT IS SHOWN, AND ALSO THE EARLY STAGE OF ELEVATION OF THE FOREHEAD FLAP.

reasonable period, the length of which will depend on the histological examination of the part removed, to ensure absence of recurrence. Figure 2071 is a drawing of a defect which has been treated in this way, and indicates the manner in which it is prepared for reception of a forehead flap.

Raising of Forehead Flap.

When the preparation of the defect is completed, a pattern of the requisite forehead flap is made, or one previously prepared is tried in

position and given any final trimming which proves necessary. The pattern is opened out and placed in such a position on the forehead as will permit of the fashioning of a pedicle which will allow it to reach its destination without undue tension (see figs. 2070 and 2071).

The sickle-shaped pedicle (so-called "up and down"), first suggested by Gillies, gives the best provision for this requirement, but *occasionally a horizontally-disposed pedicle and flap must be employed* in order to avoid hair-bearing skin on the new nose. Careful orientation of flap and pedicle is of paramount importance; it is distressing in the extreme to find that a pedicle has been cut which will not allow the flap to reach its destination. A trial should always be made with a piece of ribbon gauze or tape held along the line of the proposed incisions and brought down to the more distant points on the nose defect. Once the positions for the flap and pedicle have been accurately estimated (they may be marked out, if desired, by pen and ink), outlining incisions are made and the raising of the flap is proceeded with. The edges of the flap are handled with care, fine hooks being employed in preference to dissecting forceps. The distal portion which is to be in-turned is cut reasonably thin, superficial to the frontalis muscle, but once this portion is passed the separation is deepened to the plane of areolar tissue immediately superficial to the pericranium. The pedicle may be raised by blunt dissection with scissors or gauze, but care should be taken to avoid trauma to its vessels on the one hand, and exposure of bone on the other.

Hæmorrhage, which is liable to be free, is best controlled by pressure exerted by an assistant on the eyebrow margin and over the superficial temporal vessels. No form of tourniquet or scalp-forceps has proved satisfactory.

When the flap and pedicle have been freed, marginal bleeding vessels *on both flap and scalp are picked up in artery forceps and tied. Iced* saline compresses help to arrest oozing from the scalp defect, but must not be used on the flap, which is temporarily covered by gauze wrung out of warm saline. The flap illustrated is a fairly typical one for a case in which the nose loss is extensive. It will be noted that it has neither indentations nor narrow prolongations, and therefore possesses as perfect a blood supply as possible to all parts. The older method of making a small prolongation for the columellar region frequently led to loss of this most important part of the reconstruction, a calamity which ruined an otherwise excellent new nose. The pedicle must be kept wide, seldom narrower than the widest part of the flap.

In cases where the viability of tissues is low, as in old people, the

forehead flap may be "delayed," that is, it may be outlined by incisions but not raised at the first operation. In other cases it may be deemed advisable to raise the flap and pedicle, or some portion of them, and return them to the forehead for a short period before submitting the pedicle to the rotation necessary to bring the flap to the nose defect. Such intermediate stages, and indeed the whole reconstruction, can be carried out under local anæsthesia. This materially diminishes hæmorrhage but introduces the possibility of producing thrombosis of the main vessels of the pedicle. It may not be out of place to mention at this point that venous and possibly also lymphatic drainage of a flap is of equal importance to arterial blood supply. Indeed, in most cases of gangrene of a flap the cause may be traced to deficient venous drainage leading to congestion and thrombosis. A white flap is infinitely to be preferred to a blue one.

The distal margin of the forehead flap is now accurately sutured to the lining margins of the airways, a guide suture being first placed between its mid-point and the proposed lip columella junction. Suturing is continued laterally from this central point until the alar bases are reached, when it is continued upwards between the cheek skin edges and the lateral margins of the covering portion of the flap. On the inside of the new nose, catgut sutures, either interrupted or continuous, are employed; on the outside, interrupted silkworm-gut sutures are used.

As the suturing progresses, so the tip portion of the nose takes shape, and it is always particularly gratifying to note the way in which the tip of the nose gradually acquires very natural protrusion and the new nostril margins take on a rolled appearance (fig. 2072). Mattress sutures may be passed between lining and covering to accentuate *supra-alar hollowing*, while a similar suture passed *across the bridge* line may be employed to maintain prominence in this region and prevent hæmatoma formation. Such sutures introduce some risk of interfering with blood supply to the more distal parts of the flap. They are frequently left untied at the operation, to be tightened snugly forty-eight hours or so later if the condition of the flap warrants it.

Gentle packing of the new nostrils helps to prevent accumulation of blood between lining and covering, and so preserves their shape. Rubber tubes may be introduced for this purpose but are more liable to cause pressure necrosis. The raw surface on the forehead may be covered immediately by a Thiersch graft or may be dressed with tulle gras or ambrine. Care must be taken that the bandage holding the dressings in this region causes no pressure on the edge of the pedicle.

External sutures are removed from the nose in about five days.

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External sutures are removed from the nose in about five days.

Mattress sutures must be carefully watched lest they begin to cut in and produce necrosis.

Ten to fourteen days after the first-stage operation, the pedicle is divided from the flap. The cut edge of the flap is trimmed and sutured

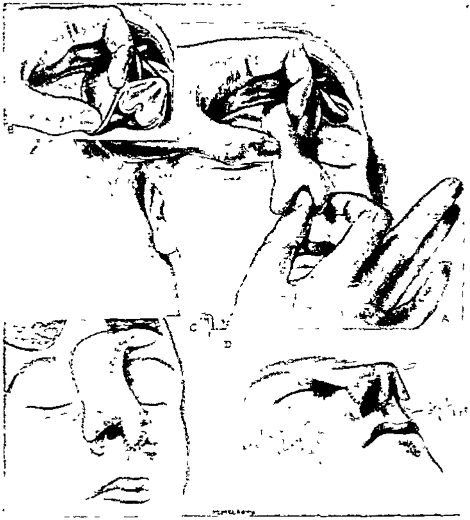

Fig. 2072.—The application of the forehead flap to the nose defect.

A. Flap in folded and tried in position.
B. Flap rotated to show nature of in folding.
C. Suturing of flap to defect has been completed on the left side. The in turned part of the flap is being sutured to the lining margin of the right airway.
D. Suturing completed. Mattress suture passed across tip of nose but not tied.

in position on the nose. A warning should be given against leaving too little skin in the flap: *it is wiser to leave too much to be trimmed to suit the defect, which is clearly visible only after division of the pedicle, than to return to the forehead even a small area of skin which one has planned so carefully to leave behind in the new nose.*

The pedicle is cleared of granulations both on its deep surface and on its edges by gentle scraping. The corresponding portion of the raw surface on the forehead is similarly cleared of granulations, and the pedicle edges are sewn back in normal position on the scalp.

When the forehead raw surface has been grafted at the first stage,

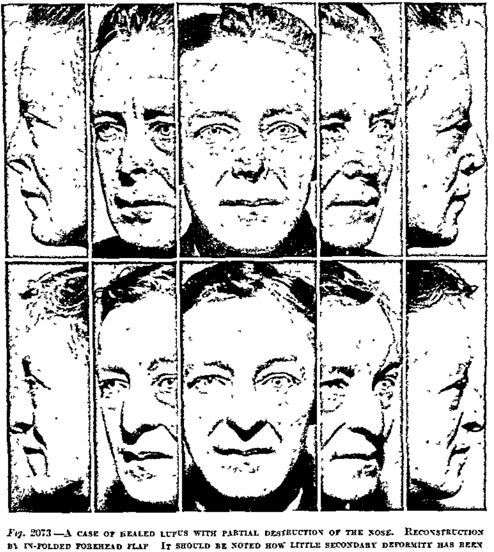

Fig. 2073.—A CASE OF HEALED LUPUS WITH PARTIAL DESTRUCTION OF THE NOSE. RECONSTRUCTION BY IN-FOLDED FOREHEAD FLAP. IT SHOULD BE NOTED HOW LITTLE SECONDARY DEFORMITY HAS BEEN PRODUCED IN THE FOREHEAD REGION.

some portion of the graft must be removed to accommodate the returned skin. If grafting has not been carried out at the first stage, the granulations may be shaved from the raw surface which remains after the return of the pedicle, and a Thiersch graft may now be applied. As raw surfaces have been exposed for some time, and infection of a mild type is therefore to be expected, it is preferable to defer grafting, place a drain under the pedicle, and apply a hot boracic

fomentation over all. Seven to fourteen days later, when healthy granulations are present, any remaining raw surface can be grafted under local anæsthesia by either Thiersch or Wolfe graft: the latter gives the more satisfactory cosmetic result. The patient is ready for discharge from hospital some 7–14 days later.

Any limited patch of hairs on the skin of the new nose, unavoidable

Fig. 2074.—A case of partial destruction of the nose due to lupus. Reconstruction by in-folded forehead flap.

in some cases where the forehead is unduly narrow, may be treated by electrolysis.

Figures 2073–2075 are records of cases treated by this method.

When the skin of the new nose has become soft and supple, definition and support may be given to the bridge line by means of a hinged cartilage graft. This is introduced via a central columellar incision and, because of the septal reconstruction given by this method of rhino-

plasty, ample room is available for the accommodation of the important columellar strut (see fig. 2084). In earlier nose reconstruction work it was customary to insert a cartilage graft in suitable position under the skin of the forehead some weeks before the forehead flap was moved. Alternatively, similar struts of cartilage were implanted under flaps which it was planned to turn in for lining the new nose with the idea of giving support to these flaps in their new position. Neither of these procedures is recommended. The latter is unnecessary, and with the

Fig 2075.—A case of chronic ulceration at the site of old lupus treated by X rays. The affected area was widely excised and the defect repaired immediately by forehead flap.

former the bridge is almost invariably incorrectly placed. It is considered a much wiser policy to reconstruct the nose in soft tissues of ample dimensions and to add the supporting structures when these, safely growing in their new position, have been rendered free of all induration by massage. Only in this way can precise definition of the bridge line and adequate support of the tip be provided.

When the degree of nose loss is extreme, a compromise must be made in regard to lining, the upper part being provided by in-turned flaps from the margins of the defect and the lower part by the forehead flap. In cases where no local material is available, the forehead flap

may be partly or wholly lined by Thiersch or Wolfe graft at a preliminary stage before it is swung down from the forehead. In exceptional cases superimposed flaps may be required, lining being provided by a tubed pedicle flap from the chest and covering by a forehead flap. In cases in which the forehead skin is scarred or when it is particularly desired to avoid producing scars in this region, a new nose may be reconstructed by means of a tubed pedicle flap transferred directly from the chest wall (fig. 2076). I have found an abdominal tubed pedicle flap, about 5 inches by 3 inches, particularly useful for nose reconstruction in these circumstances. The flap is prepared on the left lower quadrant of the abdominal wall. After a minimal interval of

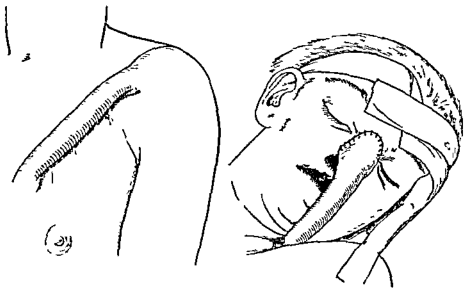

Fig. 2076.—Drawings from a case record illustrating the direct transfer of a pectoral tubed pedicle flap for reconstruction of the nose.

six weeks, during the latter half of which the patient may be out of hospital, the lower end of the flap is divided and attached to the radial border of the forearm in the manner illustrated in figure 2077. This illustration is copied from a photographic record, and it will be seen that the pedicle has been rotated so that its " seam " faces the dorsal aspect of the forearm. This rotation of the flap has never been found to interfere with its blood supply. Three weeks later the upper end is divided from the abdominal wall and about two-thirds of the flap is unrolled and cleared of excess fat. The forearm is carried across the forehead, dorsal surface backwards, where it is very readily fixed by strapping. This position causes no serious discomfort and it will readily be seen that it brings the flap into a position over the nasal defect eminently suitable for reconstruction of the nose. The stages

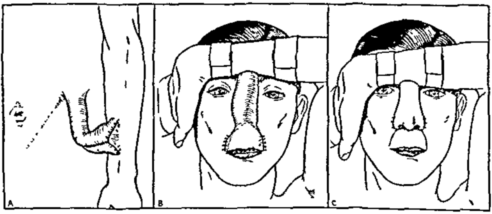

Fig 2077.—DRAWINGS ILLUSTRATING THE MANNER IN WHICH AN ABDOMINAL TUBED PEDICLE FLAP MAY BE TRANSFERRED VIA THE WRIST FOR RECONSTRUCTION OF THE UPPER LIP (B) AND AFTERWARDS FOR RECONSTRUCTION OF THE NOSE (C).

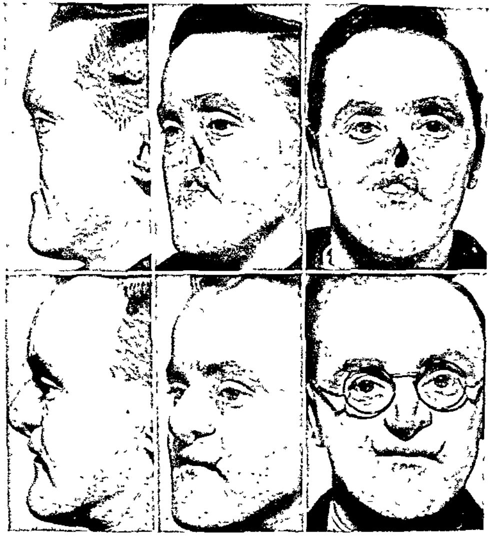

Fig 2078.—A CASE OF LUETIC DESTRUCTION OF THE NOSE AND UPPER LIP IN WHICH RECONSTRUCTION WAS CARRIED OUT IN THE MANNER SHOWN IN *Fig* 2077.

of in-turning and suturing are precisely similar to those already detailed.

In several cases such a flap has been employed to provide skin from its distal border for reconstruction of the upper lip before its more proximal part was employed in reconstructing the nose. Figure 2077 illustrates the manner in which this manœuvre is carried out. Figure 2078 is a record of a case in which this method was employed for reconstructing both lip and nose.

B. CORRECTIVE RHINOPLASTY

THE CROOKED NOSE

It is natural to expect that the most prominent feature of the facial contour will bear the brunt of the majority of facial injuries. Fractures of the bony bridge are extremely common in sports and in motoring accidents. While a nose deflected in moderate degree from the mesial plane may be insufficient to constitute serious disfigurement in a man, a similar degree of crookedness may be a very real handicap to a woman. Quite apart from cosmetic considerations, it must be remembered that the crooked nose is usually defective in function. It is true that clear nasal airways may be restored by submucous resection of the septum, but it must be obvious that this procedure is likely to give a less satisfactory result when a deflected bony framework is present than when obstruction is due entirely to deflection or deformity of the cartilaginous septum. Indeed, it would appear illogical to consider submucous resection the operation of choice in such cases. In some, correction of the bony displacement is in itself sufficient to clear the obstruction, for the septum comes over into correct position with the bone; in others, it would appear wise to aim at the maximum improvement obtainable by correction of the bony deformity, leaving any residual obstruction to be treated at a subsequent operation by submucous resection; while in still others again, it proves best to carry out a combined operation, the septal resection and the correction of the bony deformity being performed at the same sitting.

The general surgeon will take infinite pains to obtain good alignment in a fracture of a limb bone, yet the Nose and Throat specialist has, in the past, given very indifferent attention to fractures in his field of surgery. Malposition of nasal bones is frequently responsible for discomfort, and sometimes for actual pain of a neuralgic character.

RECENT FRACTURES

In fractures of the bony parts of the nose the fragments are almost invariably impacted, and simple external digital manipulation, the treatment so commonly considered sufficient, proves useless. Thorough disimpaction is the most important part of treatment. If tackled immediately after the accident, the classical method of introducing a blunt instrument of the elevator type into the nose and levering out the nasal bones should give satisfactory results. There is, however, frequently a doubt about the diagnosis, for swelling obliterates bony contours, crepitus is seldom elicited, and all manipulations are resisted on account of pain and tenderness. For these reasons early treatment, at a time when it should be relatively simple, is usually neglected altogether or is carried out in a very half-hearted manner.

For the efficient disimpaction and setting of a recent fracture of the nose, full anæsthesia is advisable. As a rule, this need be of only short duration, but if the patient is to be protected from inspiration or swallowing of blood and the surgeon saved from working in a blood-sprayed field, the anæsthetic should be administered by the intra-tracheal route. Evipan or even local anæsthesia may be employed where contra-indications to inhalation anæsthesia are present, provided efficient blood suction apparatus is available.

The operation should be carried out methodically and deliberately, and nothing should be allowed to interfere with the thoroughness of the work. No better instrument for manipulation of the fragments has been designed than the forceps originally devised by Walsham (*Lancet*, Aug. 29, 1891), and copied for me by Mayer and Phelps. These, right and left, with central or septal-setting forceps, are illustrated in use in figure 2079. The narrower blade is passed up the nose so that it comes to lie on the inner surface of the nasal bone, while the broader blade, shaped to correspond with the outer surface of the bone, is applied externally over the skin. This outer blade is usually covered by rubber tubing to avoid damage to the skin. The blades of these forceps do not meet, and there is therefore no crushing of the bone or its soft tissue coverings, yet a firm grip is obtained. The nasal bones are in turn rotated outwards to obtain thorough disimpaction. Simple external digital pressure now brings them into normal position and restores narrowness to the bony bridge. In most cases the septum has shared in the displacement, and it is always advisable to centralise this structure and at the same time correct any tendency to backward displacement of the bridge line.

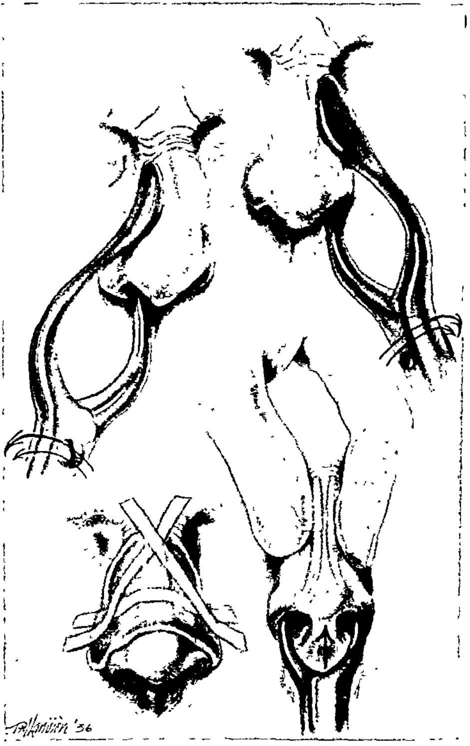

Fig. 2079.—Disimpaction and setting of a recent fracture of the nose. Walsham's forceps (right and left) and septum forceps are shown in use, and the method of splinting by Stent cast is indicated.

Splinting.

A simple method of maintaining the corrected position and preventing hæmatoma formation is as follows: a piece of sheet lead, cut to correct size and shape, is moulded to cover the front and sides of the nose. With this in position, a thin covering mould of Stent is made. This is cooled rapidly by trickling over it iced lotion from a dental chip syringe. The sheet lead, which has now served its purpose by holding the bones in position during the setting of the mould, is discarded. The mould is suitably trimmed and is strapped in position by adhesive strips passing from forehead to cheeks.

It is sound practice to pass a wick of tulle gras or of gauze soaked in liquid paraffin into each airway, not as a packing or splint but simply to prevent accumulation of blood clot which is liable to take several days to disperse. When the wicks are removed twenty-four hours later, nasal breathing is restored immediately and the patient is rendered much more comfortable. The mould may be removed at the same time or it may be retained for some days longer. It should be remembered, however, that its main function is to limit post-operative swelling and prevent re-displacement of fragments during the stage of recovery from the anæsthetic. Its retention for any length of time after it has fulfilled this function may be disadvantageous, for it is better to have the nose in full view rather than risk leaving it blindly fixed in what may prove to be a slightly incorrect position. Any tendency to re-deviation is very readily checked by digital pressure. Once disimpaction has been carried out completely—and the best criterion of this at the time of operation is that the nose can be readily pushed to the opposite side—there is very little tendency for the nose to become crooked again.

After-Care.

The majority of uncomplicated cases are kept under observation only over-night. Nostrils require gentle cleansing with hydrogen peroxide. They should then be dried and smeared with liquid paraffin. In some cases, undue swelling calls for longer after-care, and as the swelling subsides a careful watch must be maintained for any re-deviation. The patient is instructed to press in the nasal bones towards the mid-line with his fingers in order to keep the bony bridge narrow, and to press more on one side than the other should there appear to be any re-deviation during the setting process.

In cases in which the bones of the nose are extensively comminuted and when backward displacement is pronounced, the simple wire self-retaining intra-nasal splint devised by Watson Williams (*B.M.J.*,

Oct. 31, 1931), or the one introduced by A. B. K. Watkins (*B.M.J.*, Nov. 18, 1933), will be found useful. In some such cases it proves practicable to pass a silkworm-gut suture in mattress form, tied over small gauze rolls, from one side to the other, the needle finding its way between bone fragments.

In the most severe varieties of fracture, support may be obtained by extensions from a metal-cap splint fixed to the upper teeth. All such apparatus is uncomfortable to the patient. Many of the cases in which its use appears to be most clearly indicated fall into a category which calls for some secondary reconstruction of the bridge line by cartilage or other supporting graft at a later date. Although the indication to provide the best possible foundation on which to build is a clear one, careful judgment is required if over-long and futile efforts to support a badly comminuted bridge line by mechanical means are to be avoided.

Skiagrams of nasal fracture cases are seldom necessary, and unless taken by a radiologist with special experience are likely to fail to indicate the sites of fracture. They are reserved for the most part for doubtful cases in order to demonstrate to patients or parents the need for surgical interference. They are also useful as records in medico-legal cases.

It is wise in all severe nasal fracture cases to explain that the main aim of operative treatment is to correct crookedness as seen from in front, i.e., lateral deviation. It does aim, of course, at complete restoration to normal, but in some cases disturbance of the interrelation of cartilaginous and bony elements may produce some alteration in the bridge line contour as seen in profile. Another point worth mentioning is that a recently fractured nose may have been the subject of a previous fracture which has received no treatment. In such cases it is not to be expected that replacement of recently displaced fragments will reproduce a perfectly normal nose.

Probably the optimum time at which to operate on a nasal fracture is as soon as possible after the accident and before swelling has had time to appear. If this opportunity has been missed, it is as well to allow three or four days to elapse. By this time swelling has subsided to some extent, the deformity has become more obvious, and the patient is more convinced of the need for treatment.

The operation can be carried out successfully up to about three weeks after injury. After this time the bones have to a great extent "set" and manipulation by forceps is impossible or unsatisfactory.

OLD FRACTURES

When the nasal bones have become firmly set in malposition a much more complicated procedure is required to correct deformity.

Lateral vestibular incisions are made over the lower borders of the nasal bones. Through these the soft tissues are elevated on a subperiosteal plane. In order that rearrangement of the relation between skin and bone may be thorough, this undermining of soft tissues is not restricted to the regions of the nasal processes of the maxillæ but extends over the whole bridge and down towards the tip of the nose.

Lateral saw cuts are made (fig. 2080) which meet above, and the bony sides of the nose are " in-fractured " either by thumb pressure or by means of Walsham forceps.

In order to avoid unnecessary damage to the nasal mucous membrane, it is sound practice to pass the elevator upwards on the inner aspect of the bone and so separate the nasal muco-periosteum in the line of the proposed saw cut. The bony parts of the nose should be freely mobilised. The septum is manipulated into a central position, and the parts are moulded by the fingers and splinted in the manner already described for recent fractures.

In the most severe types of deformity it is essential to *excise* a wedge of bone on the longer side before the bridge can be persuaded to assume a central position.

When gross displacement or deformity of the septum is present, it is well to have the collaboration of a Nose and Throat specialist who will carry out a submucous resection of the septum first, saving the cartilage he removes for any building up of the bridge line which is required. The lateral vestibular incisions are not sutured but are left open to provide free drainage.

Careful post-operative observation of these cases is required. Digital manipulation is usually sufficient to prevent re-deviation and is preferable to the use of any form of external fixed apparatus.

THE HUMPED NOSE

The treatment of the bony hump follows closely that of the old fracture. Lateral vestibular incisions are made but these are extended forwards and then backwards on the sides of the membranous septum, which structure is transfixed (fig. 2080 [1]). Undermining is carried out as previously described. The bony hump is removed by saw, chisel, or the special instrument I have devised for this purpose illus-

trated in use in figure 2080 (2). The last mentioned has the advantage of cutting deeper as it passes downwards; chisels always tend to pass deeper as they are driven upwards and this is obviously undesirable.

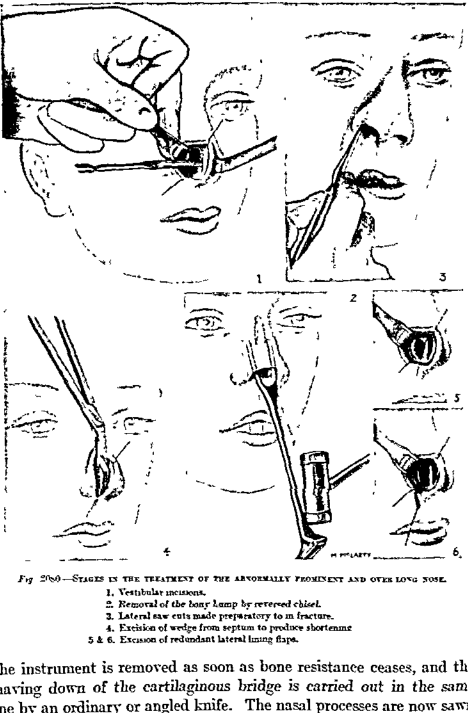

Fig 2080—STAGES IN THE TREATMENT OF THE ABNORMALLY PROMINENT AND OVER LONG NOSE.

1. Vestibular incisions.
2. *Removal of the bony hump by reversed chisel.*
3. Lateral saw cuts made preparatory to in fracture.
4. Excision of wedge from septum to produce shortening

5 & 6. Excision of redundant lateral lining flaps.

The instrument is removed as soon as bone resistance ceases, and the shaving down of the cartilaginous bridge is carried out in the same line by an ordinary or angled knife. The nasal processes are now sawn and in-fractured, and the bridge line is thus re-narrowed.

THE LONG NOSE WITH DROOPING OR WITH BULBOUS TIP

It is common to find one or both of these conditions associated with hump deformity.

Shortening of the nose and elevation of the tip are obtained by excising from the exposed lower border of the septum a triangle with its base forwards and its apex in the region of the nasal spine. The length of the base of this triangle is the index of shortening which may

Fig 2081.—AN EXAMPLE OF A RECENT NASAL FRACTURE TREATED BY DISIMPACTION AND SETTING.

be expected (fig. 2080 [4]). When the tip portion of the nose is tried in position it will be seen that there is an overlap of excess lining material on the lateral walls of the nose, and triangular areas (usually including the lower parts of the lateral [triangular] cartilages) must be removed to allow the wound edges to lie in apposition (fig. 2080 [6]). It is particularly dangerous to remove too much material in these situations, or an unpleasant " snarl " will be produced by the drag up of the nostril border.

The bulbous tip, almost invariably due to excessive bulk and

prominence of alar cartilages, is treated by careful exposure and removal of the upper halves or more of these cartilages on either side of the intercrural angles. Clearing of the cartilage is not easy, since both covering skin and lining are firmly adherent to it. Separation is facilitated by the injection of local anæsthetic or saline solution between the cartilage and its coverings. The septal incision is sutured, the stitches

Fig. 3962.—An example of an old fracture of the nose with pronounced deviation treated by submucous resection of the septum combined with surgical re-fracture and straightening

being passed in such a way as to draw the tip upwards and forwards to the desired extent. The lateral parts of the incisions are left open for drainage. Splinting is carried out as previously described, and wicks of tulle gras are passed into the airways.

It will be seen that various modifications or combinations of these procedures may be required for the infinite variety of nasal deformities encountered.

Figures 2081–2083 show examples of a recent fracture, an old fracture, and an over-long and over-prominent nose treated by the procedures described above.

Fig 2083 —AN ABNORMALLY PROMINENT AND OVER LONG NOSE TREATED BY THE TECHNIQUE SHOWN IN *Fig* 2080

THE DEPRESSED BRIDGE

Saddle Nose.

Mention has already been made of the treatment of those gross depressions of the nasal contour which follow luetic destruction of both mucosa and supporting structures. It may be repeated here, however, that the first essential in the treatment of these cases is the replacement of lost lining by Thiersch grafting. Only when the nose has been freed from the pyriform opening and brought forward as a whole is it justifiable to consider giving intrinsic support by cartilage implant. The less severe depressions of the bridge line are due to defective development, fracture, septal abscess, or excessive removal of cartilage in the surgical treatment of the deflected septum. In all these conditions the nasal contour can be satisfactorily restored by the implantation of a cartilage graft of suitable shape and size.

Where the tip of the nose is well supported, a single piece of cartilage

will achieve the desired result. Where tip support is deficient, the hinged graft (Gillies), consisting of a bridge piece and a columellar strut

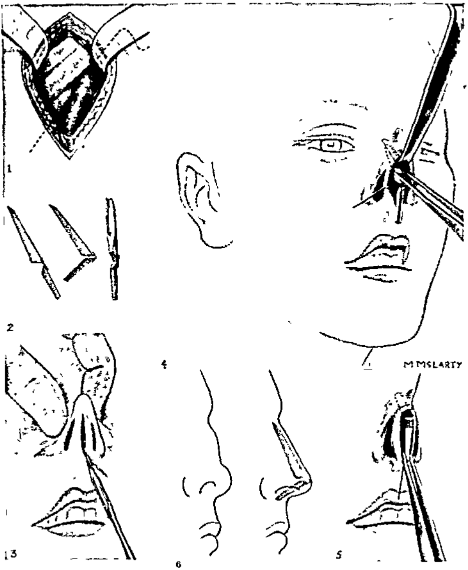

Fig 2084.—The technique of the treatment of the depressed nasal bridge by cartilage graft.

1. Exposure of costal cartilages from which the graft is usually obtained.
2. The graft prepared with perichondrial hinge. The posterior surface of the bridge piece is grooved to lie on the nasal bones above.
3. Central columellar incision giving approach for undermining of skin of nose.
4. Bridge piece of graft being inserted.
5. Columellar strut being lifted into position.
6. Outline of nose before insertion of graft. Outline with graft in position.

left attached to each other by a narrow strip of perichondrium, is required (fig. 2084). The bridge piece should be shaped to fit snugly on any remaining portion of the bony bridge, and is commonly grooved

on its posterior surface for this purpose; the columellar strut abuts against the anterior nasal spine at the base of the columella. In this way firm support and protrusion is given to the tip of the nose.

Fig. 2085.—Case record illustrating correction of the depressed nasal bridge line by cartilage graft.

In some cases, extensive undermining of skin extending well out to the sides of the nose is required; in others, a mere pocket for reception of the graft is sufficient. A graft which extends for the whole length of the nasal bridge gives a better appearance than one which runs only

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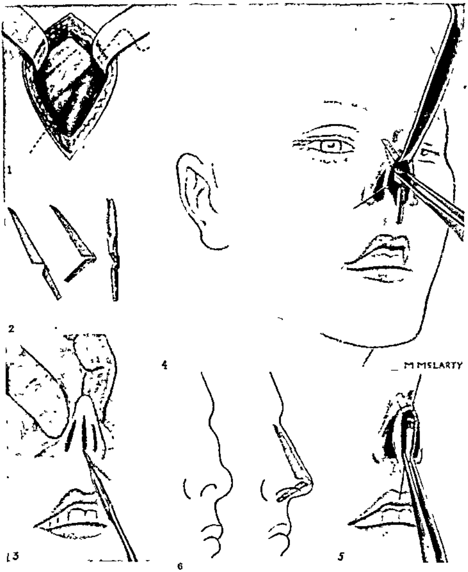

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Fig 2085.—Case record illustrating correction of the depressed nasal bridge line by cartilage graft.

In some cases, extensive undermining of skin extending well out to the sides of the nose is required; in others, a mere pocket for reception of the graft is sufficient. A graft which extends for the whole length of the nasal bridge gives a better appearance than one which runs only

part way up the nose. For this reason it has sometimes appeared wise to shave down an already high bony bridge at a preliminary operation before inserting the graft. Short of this, a graft may be notched on its posterior surface so that it abuts on the lower edge of the existing bony

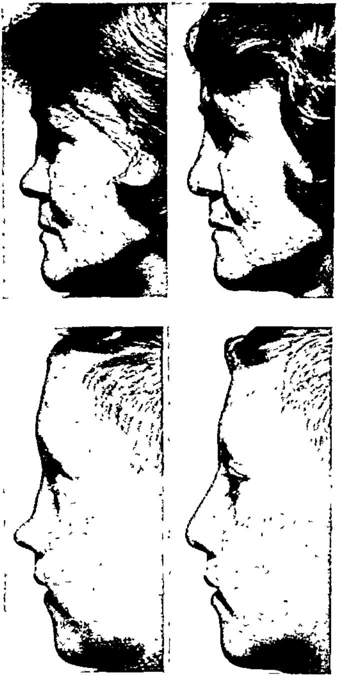


Fig. 2086.—OTHER EXAMPLES OF RESULTS OBTAINED BY NASAL CARTILAGE GRAFT.

bridge, or its upper end may be made to fit into a pocket in the same situation prepared by separating the muco-periosteum from the inner surface of the bone. The latter procedure is fraught with danger of opening into the nasal cavity, and so with risk of infection of the graft.

Nasal cartilage grafts may be inserted via: (1) an incision on the side of the membranous septum; (2) a vestibular incision where septum and lateral walls meet; (3) the columella–reflection route illustrated in figure 2087; or (4) the central columellar incision shown in figure 2084 [3].

Infection is rare; when it does occur, free drainage should be established immediately. If it fails to clear up speedily, it is wise to remove the graft completely rather than to wait for its slow extrusion or disintegration.

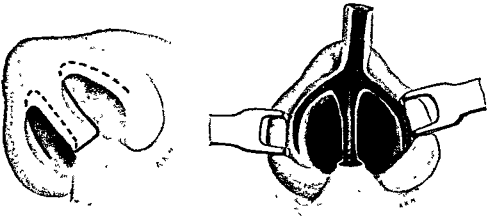
Figures 2085 and 2086 illustrate typical cases treated by cartilage grafts.

General Remarks.

Preliminary application of cocaine and adrenalin solution to the nasal mucosa makes for less bleeding and a clearer operation field.

The skin of the nose is very obliging, for it will usually shrink or stretch to accommodate itself to altered skeletal contours.

Although the incisions described above are the ones usually employed, there is no doubt that the clearest exposure for all work of this type is provided by reflection of the columella, as devised by Gillies (*Proc. Roy. Soc. Med.*, 1923) and as illustrated in figure 2087. This



A B.

Fig. 2087.—The columella-reflection approach for corrective rhinoplastic procedures.
A. Incisions. B. Columella raised and free border of septal cartilage exposed

approach entails, however, a small scar line at the junction of columella and lip, and in some cases such a scar would be very obvious and must be avoided. If the columella is to be reflected, it is well to make two fine scratches with a sharp needle across the proposed line of skin

section. These assist in accurate skin apposition at the end of the operation when the various changes which have been made in the parts make their correct interrelation a little obscure.

RHINOPHYMA

Little need be said about the treatment of this condition. In its incipient stages much may be done to check progress by carefully graduated X-ray or radium treatment. In its grosser forms, simple

Fig. 2088 —A CASE OF RHINOPHYMA TREATED BY SIMPLE SHAVING.

shaving away of the sebaceous material, thereby reducing the nose to normal proportions, gives excellent results. Such shaving leaves rosettes of epithelium derived from the sebaceous pits, and these rapidly spread to cover the whole nose with new and healthy skin. Figure 2088 shows a case treated in this manner and the result obtained three weeks after operation.

Care must be taken to avoid damage to cartilage or opening into the nose. Bleeding is apt to be alarming, but operation under local anæsthesia, and the free use of iced lotion and of carefully applied pressure-dressings do much to check this.

CHAPTER VII

Paraffinoma

Although the injection of paraffin wax is still advocated and practised by some surgeons of repute, the plastic surgeon who has had experience of the sequelæ of such treatment will find no words sufficiently strong to condemn it. Carefully employed, it represents a very simple means

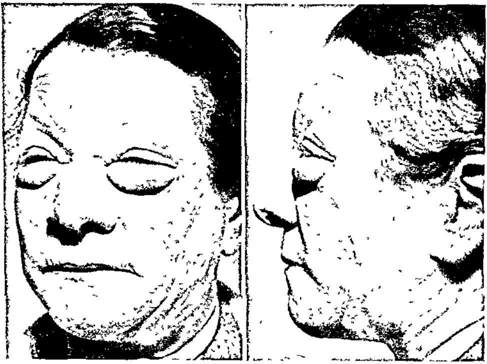


Fig 2089.—Gross lymphatic obstruction supervening many years after multiple injections of paraffin

of contour restoration in the nose, but it is never a safe method. I have never used it but I have spent many weary hours removing wax from nose, cheeks, chin and neck in cases where, frequently years after its insertion, it has become active, infiltrated the skin itself and, taking on the characters either of an infected foreign body or of a tumour, has worked its way towards the surface or even through the skin, or has gravitated into positions far removed from those of the original injections. Occasionally, it is found neatly encapsuled; its removal is

gratifying results. It is advisable that all aspects of such treatment should be fully discussed with the patient beforehand. The position and probable nature of scars, and the risks of hæmatoma formation, infection, and skin necrosis should be made perfectly clear, for it is obviously useless replacing one obsession by another. Future function of the remodelled breast should also be discussed. It is probable that little disturbance of function is produced, but it must be remembered that the heavy pendulous breast seldom contains much useful breast tissue. When a woman of child-bearing age seeks advice it is well to enquire about earlier function, about her intention to have further children and her desire to suckle them. I have no statistics on this point but Biesenberger of Vienna, who has probably devoted more thought and practice to this subject than any other single worker, claims to have many cases in which lactation and suckling have proceeded normally (even better than before) after his operations.

Careful examination should be carried out to exclude cases of carcinoma; patchy chronic mastitis need not be considered a contra-indication.

Time of Operation.

It is unwise to operate shortly after a pregnancy and before complete resolution has occurred. In order to avoid troublesome congestion and unnecessary hæmorrhage it is wise to choose a time between menstrual periods.

After trial of various procedures I have adopted as the operation of choice the one devised and fully described by Biesenberger whose book, giving a critical review of the whole subject, should be read by all surgeons embarking on this class of work.

The figures illustrating this section indicate better than words the *steps in the operation. All are based on those of Biesenberger, and only* slight modifications of the original technique have been introduced.

Although not essential and not practised by Biesenberger, some form of preliminary skin marking is distinctly helpful, for it will be seen that only slight asymmetry of position of the patient on the operating table is capable of leading the surgeon astray when he reaches the stage of placing the nipples in their new positions. Many such markings have been devised, but I have found those suggested by Claoué of Paris as reliable as any.

The patient lies comfortably on a couch with her hands on her hips and a line is drawn down the middle of the body, from the supra-sternal notch to umbilicus. A horizontal line is drawn at the upper level of the breasts and another one joining the submammary grooves. A third

horizontal line is drawn midway between the two former. Oblique lines are now drawn from the anterior axillary folds to meet at the intersection of vertical and lowest horizontal lines.

The ideal position for the new nipples lies, in my opinion, just outside and below the points of intersection of these oblique lines with the middle horizontal one. Dartigues places these points on a vertical line dropped from the junction of the outer and middle thirds of the

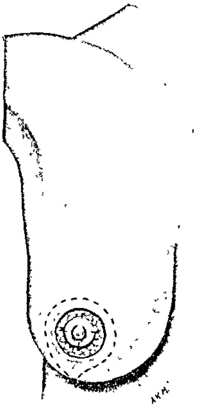


Fig 2090.—MAMMAPLASTY BIESENBERGER TECHNIQUE CIRCULAR INCISION IN AREOLAR SKIN AREOLA SUTURED AT FOUR POINTS TO BREAST. INCISION FOR REMOVAL OF PERI-AREOLAR SKIN STRIP INDICATED BY DOTTED LINE.

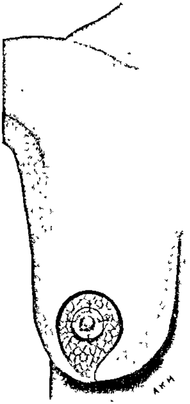


Fig 2091.—MAMMAPLASTY BIESENBERGER TECHNIQUE. PERI-AREOLAR SKIN STRIP REMOVED. VERTICAL INCISION MADE

clavicle, four finger-breadths below the axillary fold. Such markings are valuable in that they indicate points symmetrically placed ; they should not be followed slavishly, the final new position for the nipples being chosen only when the breasts have been remodelled and covered by the skin flaps.

Figure 2090 shows the incision made to liberate the nipple. This incision is not necessarily carried around the areolar margin, for the areola in cases of hypertrophy and ptosis is usually greatly enlarged. An estimate is made of the size of areola which will prove suitable for

gratifying results. It is advisable that all aspects of s should be fully discussed with the patient beforehand and probable nature of scars, and the risks of hæmato infection, and skin necrosis should be made perfectly c obviously useless replacing one obsession by another. F of the remodelled breast should also be discussed. It is little disturbance of function is produced, but it must b that the heavy pendulous breast seldom contains much tissue. When a woman of child-bearing age seeks advi enquire about earlier function, about her intention to children and her desire to suckle them. I have no sta point but Biesenberger of Vienna, who has probably thought and practice to this subject than any other claims to have many cases in which lactation and suckli ceeded normally (even better than before) after his opera

Careful examination should be carried out to exclu carcinoma; patchy chronic mastitis need not be conside indication.

Time of Operation.

It is unwise to operate shortly after a pregnancy and plete resolution has occurred. In order to avoid troublesom and unnecessary hæmorrhage it is wise to choose a tim menstrual periods.

After trial of various procedures I have adopted as the o choice the one devised and fully described by Biesenberger giving a critical review of the whole subject, should be surgeons embarking on this class of work.

The figures illustrating this section indicate better than steps in the operation. All are based on those of Biesenberge slight modifications of the original technique have been m

Although not essential and not practised by Biesenberger r of preliminary skin marking is distinctly helpful, for it will only slight asymmetry of position of the patient on the op is capable of leading the surgeon astray when he reaches placing the nipples in their new positions. Many such m been devised, but I have found those suggested by Claou reliable as any.

The patient lies comfortably on a couch with her hands and a line is drawn down the middle of the body, from the su notch to umbilicus. A horizontal line is drawn at the upp the breasts and another one joining the submammary groove

pletely exposed. This undermining is carried out chiefly by blunt dissection with a gauze swab, scissors being used to divide any adhesions which do not separate easily. A considerable amount of fat should be left on the under-surface of the skin if necrosis is to be avoided. Hæmorrhage is comparatively slight and is checked up to this stage by large gauze swabs packed into the undermined areas.

The pectoralis major above and to the outside and the serratus magnus digitations below are exposed. The greater part of the outer

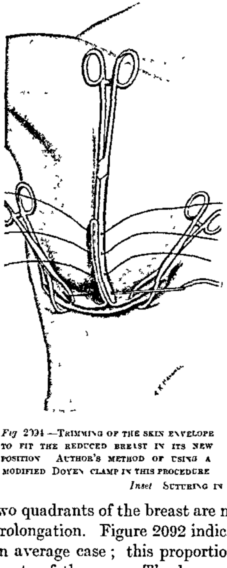


Fig 2094.—TRIMMING OF THE SKIN ENVELOPE TO FIT THE REDUCED BREAST IN ITS NEW POSITION. AUTHOR'S METHOD OF USING A MODIFIED DOYEN CLAMP IN THIS PROCEDURE.

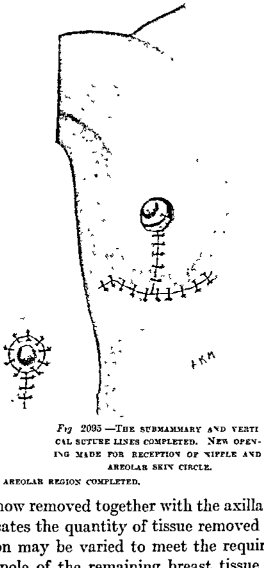


Fig 2095.—THE SUBMAMMARY AND VERTICAL SUTURE LINES COMPLETED. NEW OPENING MADE FOR RECEPTION OF NIPPLE AND AREOLAR SKIN CIRCLE.

Inset SUTURING IN AREOLAR REGION COMPLETED.

two quadrants of the breast are now removed together with the axillary prolongation. Figure 2092 indicates the quantity of tissue removed in an average case ; this proportion may be varied to meet the requirements of the case. The lower pole of the remaining breast tissue is now freed sufficiently to allow it to be rotated upwards and inwards. Trial is made of the position giving most æsthetic shape to the new breast, and when this position has been found sutures are inserted (as indicated in fig. 2093) to maintain the improved position. These catgut sutures should not take unduly large bites of breast tissue.

the reduced size of the breast. A further circular incision is now made about $\frac{3}{8}$-inch outside the former, and the ring of skin thus isolated is *stripped off the underlying breast tissue. Removal of the skin in this* manner prevents damage to the peri-areolar venous plexus, avoids troublesome hæmorrhage and gives less interference with the blood supply of the nipple than would knife dissection.

In cases where enlargement is considerable and ample skin is available, this second incision may be carried down to the submammary

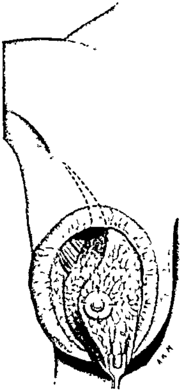


Fig 2092.—MAMMAPLASTY: BIESENBERGER TECHNIQUE. SKIN ENVELOPE SEPARATED FROM BREAST. OUTER QUADRANTS REMOVED BY "S SHAPED" INCISION.

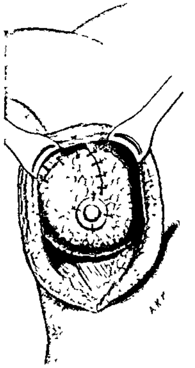


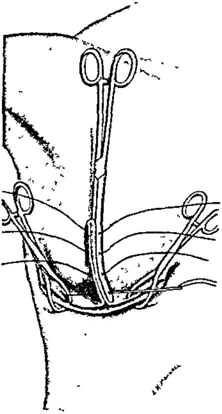
Fig 2093.—LOWER POLE OF REMAINING BREAST MATERIAL ROTATED AND FIXED TO BREAST TISSUE ABOVE AND TO PECTORAL FASCIA MARGINALLY. THIS MANŒUVRE RESTORES CONICAL FORM TO THE BREAST IN ITS NEW POSITION.

sulcus as in figure 2091. In other cases a vertical incision is made to the same point. Four fine sutures are inserted to fix the areolar skin to the breast tissue. This is an important point in technique, for the further manipulations are otherwise liable to pull on this skin and produce drag on the nipple itself.

The skin envelope covering the breast is now undermined in all directions, extensively above and to the outer side, and less extensively over the inner quadrants of the breast, until the breast is almost com-

pletely exposed. This undermining is carried out chiefly by blunt dissection with a gauze swab, scissors being used to divide any adhesions which do not separate easily. A considerable amount of fat should be left on the under-surface of the skin if necrosis is to be avoided. Hæmorrhage is comparatively slight and is checked up to this stage by large gauze swabs packed into the undermined areas.

The pectoralis major above and to the outside and the serratus magnus digitations below are exposed. The greater part of the outer



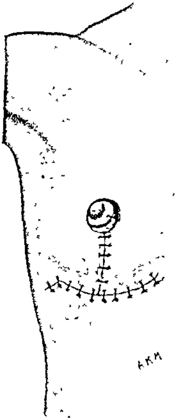


Fig 2094.—Trimming of the skin envelope to fit the reduced breast in its new position. Author's method of using a modified Doyen clamp in this procedure.

Fig 2095.—The submammary and vertical suture lines completed. New opening made for reception of nipple and areolar skin circle.

Inset Suturing in areolar region completed.

two quadrants of the breast are now removed together with the axillary prolongation. Figure 2092 indicates the quantity of tissue removed in an average case ; this proportion may be varied to meet the requirements of the case. The lower pole of the remaining breast tissue is now freed sufficiently to allow it to be rotated upwards and inwards. Trial is made of the position giving most æsthetic shape to the new breast, and when this position has been found sutures are inserted (as indicated in fig. 2093) to maintain the improved position. These catgut sutures should not take unduly large bites of breast tissue.

The breast should now occupy the desired position irrespective of skin covering, for no amount of shaping of the skin envelope will keep a badly remodelled breast in good shape.

The skin flap is now drawn over the breast and suitably trimmed. Figure 2094 indicates the device I have adopted for trial of the amount of skin excision required in the vertical direction. The skin is drawn through the modified Doyen stomach clamp until it fits snugly to the

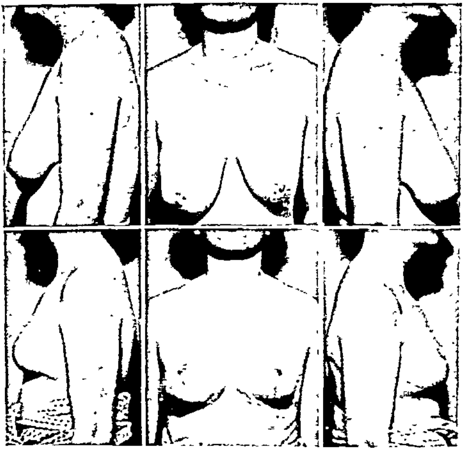


Fig. 2096.—Breast reduction and elevation in a case of asymmetrical enlargement and ptosis.

lower part of the circumference of the breast. Long straight needles armed with sutures are then passed through the holes in the blades of the clamp, the projecting skin is shaved off and the sutures are drawn through. The clamp is now removed and the sutures are tied.

A large fold of skin still remains in the region of the submammary sulcus. This is carefully trimmed away in such a manner as to keep the resulting suture line snugly placed under the breast in its new position. Every effort should be made to limit the inward prolongation of this

suture line. Its outer end should be kept well down or it will be liable to show when evening dress is worn.

Figure 2095 shows how a good finish may be obtained by carrying the outer extremity downwards a little and trimming the lower edge of a triangle at its outer end.

Further fine sutures are employed to complete the approximation

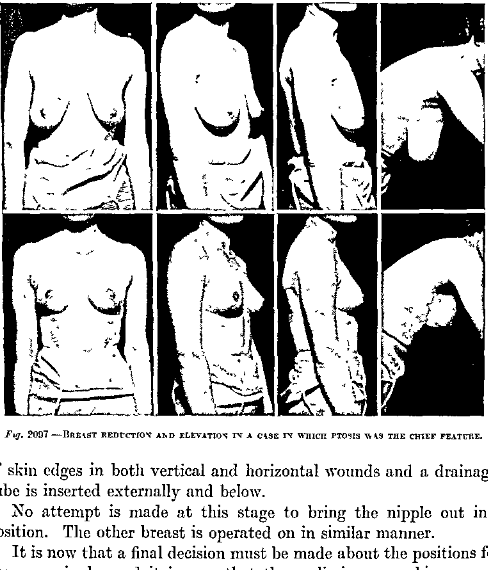


Fig. 2097.—Breast reduction and elevation in a case in which ptosis was the chief feature.

of skin edges in both vertical and horizontal wounds and a drainage-tube is inserted externally and below.

No attempt is made at this stage to bring the nipple out into position. The other breast is operated on in similar manner.

It is now that a final decision must be made about the positions for the new nipples and it is now that the preliminary markings prove helpful. Sites are chosen, not precisely at the centres of the eminences but a little below and outside these points. Various writers have suggested that, following the dictates of ancient sculpture, they should be placed above and outside these points, but experience indicates that the tendency is to place them too high rather than too low.

Circles of skin are removed similar in size to the areolar skin isolated

The breast should now occupy the desired position irrespective of skin covering, for no amount of shaping of the skin envelope will keep a badly remodelled breast in good shape.

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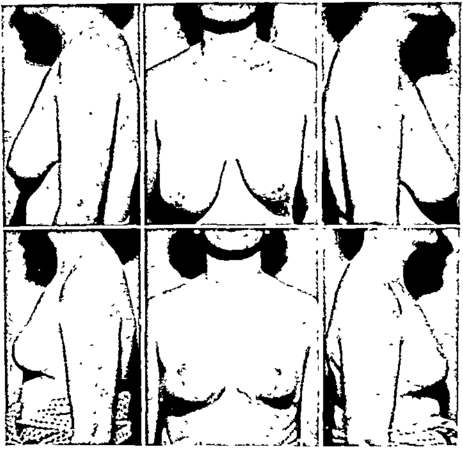

Fig 2096.—Breast reduction and elevation in a case of asymmetrical enlargement and ptosis.

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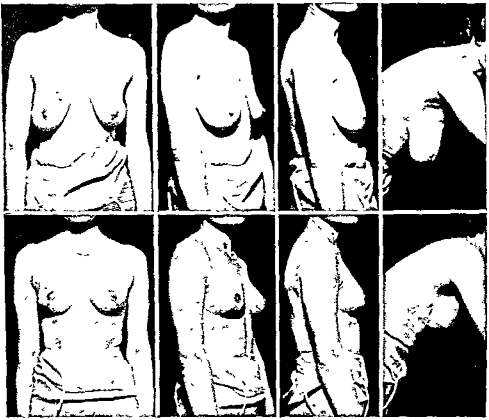

Fig. 2097.—BREAST REDUCTION AND ELEVATION IN A CASE IN WHICH PTOSIS WAS THE CHIEF FEATURE

of skin edges in both vertical and horizontal wounds and a drainage-tube is inserted externally and below.

No attempt is made at this stage to bring the nipple out into position. The other breast is operated on in similar manner.

It is now that a final decision must be made about the positions for the new nipples and it is now that the preliminary markings prove helpful. Sites are chosen, not precisely at the centres of the eminences but a little below and outside these points. Various writers have suggested that, following the dictates of ancient sculpture, they should be placed above and outside these points, but experience indicates that the tendency is to place them too high rather than too low.

Circles of skin are removed similar in size to the areolar skin isolated

by the initial incisions around the nipples. The nipples are brought out and marginal sutures are inserted, the preliminary fixation sutures being removed. Ideally the nipple should be found lying immediately under the new opening made for its reception, but occasionally some readjustment will be required; a plicating suture in the breast tissue, external

Fig. 2098.—Reduction and elevation in a case in which both enlargement and ptosis were severe. In this case secondary reduction of the lower part of the "new" breast was carried out some months after the first operation.

or internal to the nipple, is usually sufficient for this purpose. Nothing is more disappointing in results than the production of a nipple and areola which give the appearance of being dragged backwards and downwards through the skin opening. To avoid early drag of this kind—if the operation has been carried out perfectly there will be none—the skin surrounding the new opening may be "tacked" down to the breast tissue surrounding the nipple by an occasional mattress suture.

Tulle gras is applied over the nipples. The other suture lines are smeared with sterilised vaseline and covered by gauze. Copious cotton-wool dressings are used and a many-tailed bandage is applied to give snug pressure and support. A careful watch is kept for discolouration and threatened necrosis of the areolar skin, warm saline compresses being applied if necessary.

Drainage-tubes are removed in forty-eight hours. Sutures are removed gradually, some as early as the fifth post-operative day, others not until sound healing has occurred in from 7–10 days. Arm movements are restricted for about fourteen days.

For the first forty-eight hours or so patients show the ordinary after-effects of any prolonged operative procedure. After that time they seldom experience serious discomfort, and discharge from hospital is usually possible in fourteen days. The skin flap to the outer side of the vertical incision frequently becomes discoloured and occasionally shows superficial necrosis. In the early stages hot saline compresses are useful. When necrosis is established it is best to keep the parts dry.

Photographic records of cases operated on in this manner are presented in figures 2096 and 2097.

In most cases it is possible to achieve the desired reduction and elevation in a one-stage operation. In cases of gross enlargement the same operative procedure is adopted, but at a later date the vertical and submammary scar lines are reopened, excess of deep tissue is removed in wedge form, and the skin edges are suitably trimmed and re-sutured. Figure 2098 illustrates a case treated in this manner, the photographs showing the original, the intermediate and the final contour.

After operation patients are advised to wear a supporting brassière for some 4–6 weeks and to avoid any exercise involving active movements of the arms during that period.

Areas of induration and tenderness may persist for some weeks but these need cause no anxiety.

CHAPTER IX

Cleft Lip and Palate

There could be no more fascinating branch of reconstructive surgery than that which deals with the repair of congenital defects of the lip and palate; there is no work in which surgical judgment and meticulous atraumatic technique are more in demand; and there is no work in which collaboration with colleagues—pædiatrician, dental surgeon, and speech therapist—is more essential.

The vast literature of the subject is, in itself, evidence that many of the problems presented by these cases have not yet been solved, and this is not surprising when the infinite variation in type and the multiplicity of the factors involved are borne in mind. It would appear unwise to occupy valuable space by descriptions of classical operations or by arguments about the relative advantages of this or that procedure. Many years' experience of this class of work has led me to a selection of procedures which appears to offer the best possible chance of achieving the objects of treatment. It is, in this connection, a mistake to separate a lip cleft from a concomitant cleft of the alveolus and palate; on the treatment of one hangs the treatment of the other; only when the alveolus is intact can the two parts of the cleft be considered apart. I am in the habit of classifying cases in the manner suggested by R. P. Ritchie of St. Paul and have found this of great advantage:

CLASSIFICATION

Group I. Pre-alveolar Clefts.
Group II. Post-alveolar Clefts.
Group III. Alveolar Clefts.

Clefts falling into Groups I and II may present themselves in the same case; there may be a cleft of varying extent of the lip associated with a cleft of varying extent of the palate separated by an intact bridge of alveolar margin and a varying amount of un-cleft palatal tissue.

Clefts in Group III may be of almost endless variety. In unilateral complete clefts in this group it is usual to find the vomer attached, for a

varying distance, to the palatal process of the side away from the lip cleft. In bilateral complete clefts the vomer is central and unattached to either palatal process.

Pre-alveolar lip clefts may be unilateral or bilateral and may be complete (passing upwards to divide the nostril floor) or incomplete. Alveolar clefts may similarly be unilateral or bilateral, and complete or incomplete, varying from a mere notch of the alveolar margin on one side to the wide separation of the alveolar elements seen in its most severe form in those bilateral complete clefts of lip and palate in which the prolabium and premaxilla are situated far forwards and form a mere tubercle attached to the tip of the nose. Post-alveolar clefts vary from a mere split of the uvula to the long complete cleft reaching from uvula to alveolus.

Some rational classification of this kind is essential if reliable comparison is to be made in the results of operative treatment, for the type of cleft makes all the difference to the results which may be expected.

OBJECTS OF OPERATIVE TREATMENT

These may be summarised briefly as follows :

(1) To make the patient look well.
(2) To make the patient eat well.
(3) To make the patient speak well.

Of these the last is considered to be of greatest importance.

The patient can be made to look well by careful repair of the split tissues of the lip and nose. Repair in layers—skin, muscle, and mucosa —with meticulous attention to the correct placing of these tissues, with avoidance of waste of the available material and without unnecessary scarring, will achieve this object. The technical difficulties vary enormously, however, for while the repair of a pre-alveolar cleft is relatively simple, the arranging of tissues in a wide alveolar (Group III) cleft becomes a most difficult and complicated procedure. Indeed, in these latter cases, in which the bony parts are in abnormal position, it is impossible (and unwise) to make a lip and nostril which, at the time of operation, have a normal appearance. The main object of operation on such cases should be anatomical replacement of parts. It is surprising and gratifying to note that when this has been successfully achieved the lip and nostril show steady improvement in appearance as the action of the repaired lip succeeds in moulding the underlying skeletal deformity. It is for this reason that early operation (usually within the first 4–8 weeks) is advocated on lip clefts in this group.

ensures eversion of edges and prevents any unsightly notch formation in this region. All skin stitching is carried out with finest ophthalmic silkworm-gut mounted on atraumatic needles (plastasutes). Tension skin sutures have no place in lip repair work.

The first skin suture is placed at the skin-vermilion junction line and must be introduced with great care. In order to avoid irregularity of union in this region and to avoid the difficulty sometimes experienced in seeing this line at a later stage in the operation, I frequently mark it at the beginning of the operation with Bonney's Blue applied on a fine

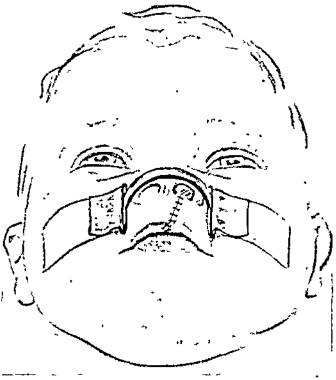

Fig 2100.—Logan's tension-bow applied.

mapping pen. Gentle tension on this first stitch brings the skin edges into correct apposition, and some five or six further sutures complete the skin closure.

All that now remains is to deal with the mucosal tags. A decision must be made as to how much can be safely trimmed away and whether imbrication or the formation of a flap from the outer side, to increase the prominence of the central part of the lip border, is advisable. Even in this limited region the formation of a flap of any material dimensions is to be avoided. It is wise to leave too much mucosa rather than too little; projections are very easy to remove later on if the cosmetic result is imperfect.

At the end of the operation a Logan's tension-bow is applied to prevent early drag on the suture line when the child cries. This device leaves the suture line exposed for periodical cleansing and for later removal of sutures (fig. 2100).

Sutures are removed as soon as possible. With the bow in position,

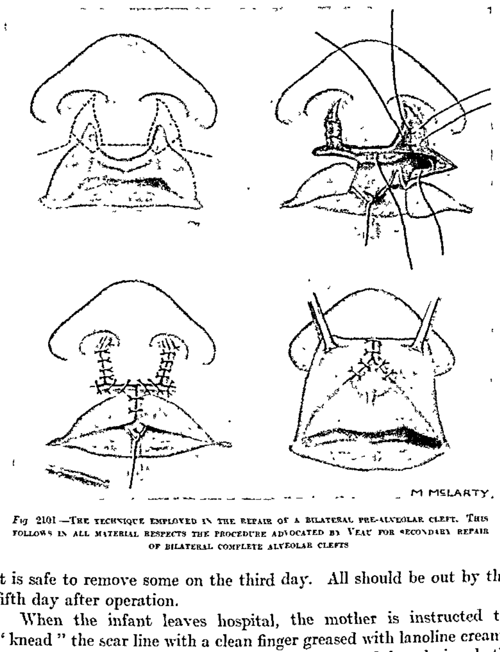

Fig 2101 — The technique employed in the repair of a bilateral pre-alveolar cleft. This follows in all material respects the procedure advocated by Veau for secondary repair of bilateral complete alveolar clefts

it is safe to remove some on the third day. All should be out by the fifth day after operation.

When the infant leaves hospital, the mother is instructed to "knead" the scar line with a clean finger greased with lanoline cream.

Bilateral pre-alveolar lip clefts may be treated by closing both clefts in this manner at the same operation. In the majority of such cases the central element is poorly developed and it is obvious that the prolabial skin should not be incorporated in the whole length of the lip.

It is in these cases that I break the self-imposed rule of avoiding the formation of flaps and repair the lip on the lines originally advocated by Veau as a secondary procedure for Group III bilateral clefts. Figure 2101 indicates clearly the technique employed.

Treatment in this group of cases is concerned almost entirely with appearance, but it should be remembered that an inferior lip repair may

Fig 2102.—Four examples of results obtained by the simple repair in layers of pre alveolar clefts. The final photograph of the adult patient is a studio portrait.

be responsible for incorrect production of labial sounds. Figure 2102 shows photographic records of clefts falling into this group and the results obtained by the simple form of repair described.

POST-ALVEOLAR CLEFTS. GROUP II

Clefts of the Palate.

In this group of cases treatment concerns itself almost entirely with providing the patient with a mechanism which will allow him to produce all the sounds necessary for normal speech.

The intact alveolar margin will, in the absence of gross and inexcusable trauma, prevent the occurrence of those appalling distortions of the dental arcade which are so frequently seen in Group III cases where closure of the palate cleft has been achieved by flaps drawn together under tension and with the formation of massive scar tissue. Masticatory disability should, therefore, never be seen in this group of cases.

How are the objects of operative treatment to be attained?

By the complete closure of the cleft, if possible, but more particularly by the provision of a mechanism by which the nose can be shut off from the mouth. No operation which fails in this latter respect can be considered successful. In the past, surgeons were satisfied if they could exhibit completely closed palate defects, and much time and ingenuity has been expended on ways and means of achieving such results. To-day the tongue depressor and inspection lamp should play no primary part in the examination of repaired palates. If the patient can speak clearly and naturally, and if he can snort and carry out those simple blowing tests which indicate efficient oro-nasal sphincteric control (Wardill), no visual examination is needed to decide whether the repair operation has been a successful one.

It is in the treatment of this group of cases, and into this group fall those Group III cases in which the lip cleft and the anterior part of the hard palate cleft have been repaired, that I have freely borrowed from the work or my contemporaries, gradually evolving a procedure which has for some years now been giving most gratifying speech results. Carried out before the child has made serious use of its defective speech mechanism, this operative technique succeeds, in a large proportion of cases, in giving normal speech without need for speech-training other than that provided by the child's natural speech trainers, its parents.

Space will not allow of both detailed written descriptions and illustrations and I have therefore considered it advisable to concentrate on the latter, reference to which should make the steps of the operation amply clear (figs. 2103–2105).

The essential points may be summarised as follows:

(1) *Pharyngoplasty.* (Wardill.)

(2) *Rotation flaps* from the hard palate. (Veau.)

(3) Extensive freeing of the soft palate tissues from the posterior borders of the palatal processes.
Free separation of nasal muco-periosteal flaps and approximation of these as far as possible throughout the cleft. (Veau.)
Employment of vomerine flap or flaps, when available, to assist in this nasal closure. (Veau.)

(4) *Hamular process fracture,* a procedure introduced many years ago by Billroth and re-introduced by Wardill and certain American workers in comparatively recent years.

(5) Free separation of the lateral pharyngeal wall from the internal pterygoid plate and its immediate neighbourhood. (Ernst and Axhausen.)

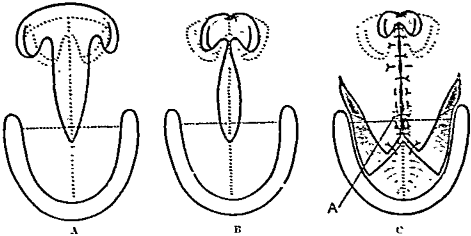

Fig. 2103.—Diagrams illustrating: (A) A post alveolar cleft of average proportions; (B) The effect of Wardill's pharyngoplasty; and (C) Repair of the cleft completed.

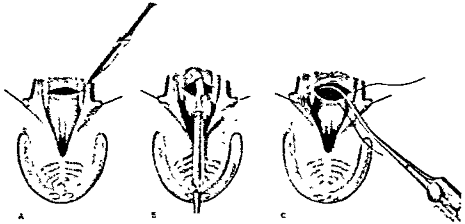

Fig. 2104.—Wardill's pharyngoplasty

A. Incision.

B. Separation of mucosa and muscle.

C. The central catgut suture being passed by a Reverdin needle

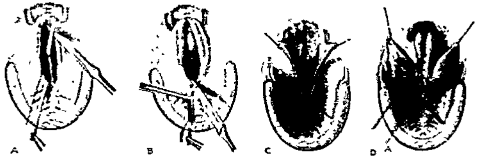

Fig. 2105.—Details of palate repair technique.

A. Paring the edges of the soft palate elements.

B. Completing the freshening at the anterior angle of the cleft.

C. Soft palate elements retracted to show pharyngoplasty suture line. Incisions marking out Veau flaps.

D. The hard palate flaps raised and freed. The nasal muco-periosteum has been elevated from the palatal processes, and some of the points of suture of the nasal layer are completed. The suture "A" is of silk worm-gut, and is later passed through the hard palate flaps and tied as shown in *Fig.* 2103 (c).

The reference after each is given not as indicating so much the original introducer as the surgeon in whose work I first observed this part of the technique.

Some general remarks on these procedures must be made.

In my opinion, the most important among the many infinitely important contributions which Veau has made to this subject is the introduction of rotation flaps to replace the older Langenbeck sliding or advancement flaps. These have enabled the surgeon to put into practice that very useful " V-Y " advancement principle, well known in other branches of plastic surgery, and so displace all available palatal material backwards to the situation where it is most needed. But this flap formation would be useless without the extensive freeing of parts on both upper and lower aspects of the bony processes which we also owe to the same worker. Veau seems inclined to attach less importance than I think should be given to the free separation of the soft tissues of the soft palate from the posterior borders of the bony processes, for without this, full posterior displacement of parts cannot be obtained. All this separation is carried out without dividing mucous membrane in the manner which formed an important part of the Langenbeck procedure.

It will be seen that when everything is ready for suture the palatal process has been completely " filleted " from its soft tissue coverings.

Veau's contributions to the repair of the palate cleft, however, begin before the main part of the cleft is tackled. The closure of any Group III cleft is facilitated in spectacular manner when the lip closure is combined with closure of the anterior part of the hard palate cleft in the manner advised by him and described later.

Trials of Veau's submucous wire suture (*suture musculaire*) left me dissatisfied. It achieved its object in preventing disunion of the soft palate suture line but was abandoned, in favour of hamular process fracture, as an unsurgical procedure producing fibrosis in its track which was likely to diminish the free mobility of the reconstructed soft palate.

Wardill demonstrated that the tensor palati muscle, the action of which fracture of the hamular process might be expected to disturb, is concerned more with deglutition than with speech. Its contraction draws the soft palate forwards, and from the speech point of view it is therefore better out of action. There is no doubt about the relaxation given by fracture of the hamular processes, and I have seen no disability produced by the procedure. It seems probable that the hamular processes become reunited in changed position and that the pull of the tensor palati thus adjusts itself to the changed position of parts. It

may even be true that in these circumstances this muscle changes its function and becomes an additional elevator of the palate, as suggested by Dorrance.

It was the uniformly good speech results produced by Wardill, in what was at the time a small series of cases, which led me to adopt his pharyngoplasty procedure as a routine measure.

In most cases, if not in all, the oro-nasal isthmus possesses abnormally large dimensions. As far as possible these were reduced by posterior displacement of the palatal tissues, but it seemed reasonable to add to this necessarily limited manœuvre anything which would bring the side walls inwards and the posterior wall forwards.

Wardill's pharyngoplasty, together with the lateral separation practised by Ernst and Axhausen, appears to be the best method available for the purpose, though it is realised that the spectacular immediate effects of these procedures do not persist in their full form. Even scar tissue in these regions must prove helpful, however, and infinitely superior to such procedures as paraffin injection or the implantation of fat, fascia, or cartilage grafts.

The illustrations show the stages of operation on a central cleft of limited length; it will readily be seen how these can be modified to suit clefts of different types.

When the vomer is available, the muco-periosteum from its sides supplies excellent flaps which assist in the nasal closure of the hard palate portion of the cleft. Sometimes the vomer is placed so high in the cleft that it is useful only as a point of fixation for the mattress sutures which draw the buccal flaps upwards into contact with the nasal flaps. Occasionally this object must be achieved by a suture drawn out through one of the nostrils and anchored by tying over a gauze roll. All these points in technique have been borrowed from Veau's work.

I do not divide the posterior palatine arteries as a routine, though Wardill holds that this is frequently necessary if complete freeing of the flaps is to be obtained; but occasionally, when the buccal flap is short and therefore in no danger of necrosis and when division of the artery promises to give greater freedom, I do not hesitate to ligature and divide it.

Wardill has recently introduced what he has described as a "four-flap method," and I have found this useful for closing wide clefts which extend far forwards. Short Veau flaps are made and extensively freed in the manner here described, and their arteries are divided if considered advisable. Anterior flaps, based on the anterior palatine

arteries, are then freed and rotated to meet in the middle line. It will be seen that this important modification of technique provides a means of avoiding or minimising the anterior defect which is left when long buccal flaps are cut and swung inwards and backwards. It also reduces the chances of flap necrosis in those cases in which complete freeing calls for division of the posterior palatine vessels.

ALVEOLAR CLEFTS. GROUP III

The widely separated elements of the gum margins in both unilateral and bilateral complete clefts of lip, alveolus and palate, give an opportunity not to be missed for dealing with the anterior part of the hard palate cleft when the lip repair is carried out. The Veau procedure in this region provides the only rational method of making a floor for the vestibule and a reasonable shape for the nostril. Further, it repairs the parts in correct anatomical manner, turning up into the nose vomerine muco-periosteum which belongs to the nose and which should not remain exposed in the roof of the mouth. It is impossible to achieve this with anything like the same satisfaction, if at all, later on when the lip is closed and the alveolar elements have approximated.

It is difficult to prepare illustrations indicating all points in this work because of the different planes concerned, but the subsequent figures show with reasonable clarity the several stages of the repair.

The operation on the palate is simple and need occupy very little time. The incision to free the vomerine flap is made first. It continues forwards and upwards behind the stump of the medial alveolar element on to the side of the septum immediately behind the columella (fig. 2106A). The flap is readily separated from the bone and is reflected upwards and outwards. Bleeding is checked by swab pressure.

The buccal flap on the lateral palatal element is now raised (fig. 2106B). This flap comes away from the bone readily, and it has never seemed necessary to make an incision along the outer border of the palate cleft. Hæmorrhage is again checked either by swab pressure or by pressing the flap firmly against the bone from which it has been raised.

I have found it of advantage at this point to forsake the strict Veau technique which completes the palatal part of the operation straight away.

Incisions are made in the lip and nostril. Those in the lip differ in no material way from those already described for pre-alveolar clefts. Mucosal tags are turned down from the margins of the cleft, but separation into layers is deferred until a later stage in order to diminish hæmorrhage. Incisions are made so as to outline a small triangular alar

base flap. The upper of these incisions is carried for a short distance upwards and backwards on the outer wall of the vestibule.

An incision is carried outwards in the gingival sulcus, and the soft parts forming the lip and the alar base are now carefully and freely

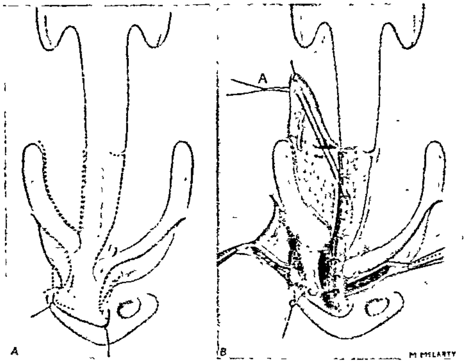

Fig. 2106.—Semi-diagrammatic drawings illustrating the technique employed at the first operation on a left complete unilateral alveolar cleft.

A. Incisions for freeing vomerine and hard palate flaps. The incisions in the lip region are similar to those shown in *Fig.* 2099. The base of the left ala has been freed for transposition later to the side of the septum.

B. The raising of the left lip element and the left alar base has exposed the ascending process of the maxilla. The vomerine flap has been sutured to the muco-periosteal flap obtained from the upper surface of the left palatal process and the side wall of the nose, and a floor for this part of the nose has thus been formed. The end of the suture "A" of silkworm gut, passed before the vomerine flap was sutured, has been carried through the hard palate flap and is ready to draw the latter over towards the right to cover over part of the raw surface exposed to the mouth.

C. The lip is repaired, as shown in *Fig.* 2099, by muco-muscular and skin sutures. The alar base flap is sutured into the triangular gap on the side of the septum and provides a good threshold for the nostril.

separated from the bone. This separation exposes clearly the ascending process of the maxilla (fig. 2106B). The muco-periosteum on the inner aspect of this process, i.e., on the lateral wall of the nasal fossa, is now separated. It comes away very readily and carries with it the inferior turbinate.

The separation is carried downwards on to the upper surface of the

palatal process, and a flap of nasal muco-periosteum is thus freed for the whole length of the hard palate cleft for later approximation to the free margin of the previously separated vomerine flap.

A silkworm-gut suture (A) is passed by a Reverdin needle through the vomerine flap in mattress form. The loop of this stitch is on the mucous surface, while its free ends emerge from its raw surface and are temporarily held out of the way in forceps. A number of catgut sutures are now

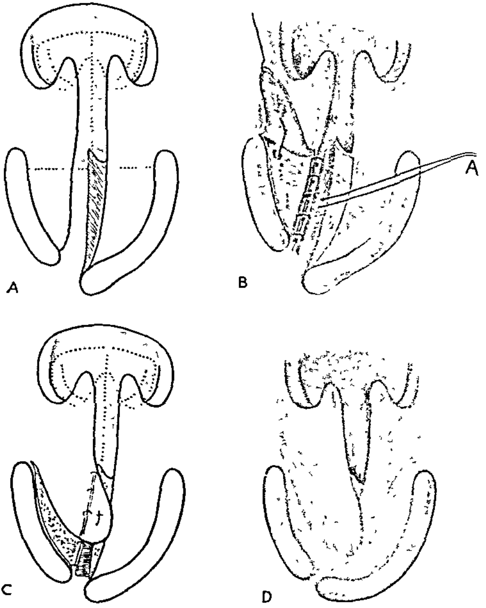

Fig 2107.—REPAIR OF LEFT UNILATERAL COMPLETE ALVEOLAR CLEFT.

A. Average cleft of this type

B. Vomerine and lateral nasal flaps sutured. Hard palate flap raised.

C. Hard palate flap superimposed on suture line and anchored by suture A.

D. Appearance of cleft of this type at time of palate repair 12 months after first operation. The appearance is similar in most respects to that presented by the post-alveolar cleft shown in *Fig.* 2103.

employed to approximate the edges of vomerine and lateral nasal flaps. These are passed by a Reverdin needle and are so arranged that their knots lie above. They are most readily passed from behind forwards and should be tied as they are introduced. The approximation of these flaps reconstructs the floor of the nose (fig. 2106B).

The ends of the vomerine flap suture are now passed through the buccal flap and tied. This brings the buccal flap over a considerable part of the suture line and reduces exposed raw surface to a minimum. The palate part of the operation is now complete (fig. 2107C).

The *remainder* of the operation follows closely that already described for closure of simpler lip clefts. The alar base flap is advanced to the side of the septum, where it is sewn into the triangular defect produced by the reflection of the vomerine flap. A few further points of suture

Fig. 2108.—Records showing results in lip and nostril regions obtained in complete unilateral alveolar clefts in two cases.

attach the upper margin of this flap to the anterior edge of the newly-constructed nasal floor. The position of this flap is shown in figure 2106C, but sutures have been omitted to avoid confusion.

The lip elements are approximated by muco-muscular catgut sutures and silkworm-gut skin approximation sutures. A Logan's bow is applied.

Figure 2108 shows photographic records of two cases treated in this manner.

Bilateral clefts are treated in precisely similar manner, but in two sittings. The lip result in such cases calls for secondary correction on the lines originally described by Veau and already mentioned in connection with those bilateral pre-alveolar clefts in which the prolabial element is under-developed.

Figures 2109–2112 show photographic records of cases of bilateral complete clefts in different stages of treatment.

It will be noted that no attempt is made in such bilateral cases to displace the premaxilla backwards by wedge excision from the vomer or by other means. The lateral lip elements are brought forward to it in its abnormally protruded position. This maintains a natural harmony

Fig. 2109.—A case of bilateral complete cleft of lip, alveolus and palate showing the result to be expected from repair of the lip in two stages. Secondary repair will give greater depth to the centre part of the lip, narrow the nostrils, and allow the prolabium and the tip of the nose to come forward.

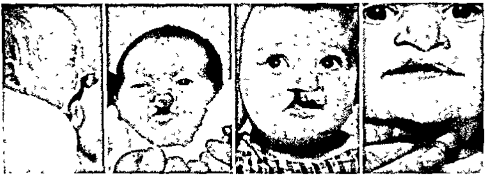

Fig. 2010.—A similar case showing the intermediate stage after closure of the left lip cleft.

Fig. 2111.—The result of repair of bilateral complete alveolar cleft. The lip and anterior part of the hard palate were reconstructed in two stages. The remainder of the palate cleft was repaired twelve months later. A secondary operation of the type illustrated in *Fig.* 2101 had been carried out a short time before the last photograph was taken.

Fig. 2112.—A case of bilateral complete alveolar cleft treated in similar manner to that shown in *Fig.* 2111.

in the relation of nose and lip, and avoids the very ugly, flat, retroposed lip which results from backward displacement of the premaxilla and closure of both lip clefts at one sitting. Gradual moulding of the premaxilla into better position is produced by the continual muscular contractions of the lip. In nearly all bilateral clefts of this group, however, further work is required later on, and in some cases the premaxilla is removed entirely and its place taken by a denture providing incisor teeth in correct alignment with the other upper teeth.

There are other varieties of cleft which have not been considered. Only one of these will be mentioned. The alveolus may be cleft on one side or on both, yet there may be no cleft of the palate proper. In the bilateral cleft of lip and alveolus of this type, protrusion of the premaxilla may be so marked as to call for lip repair in two stages, but in the majority repair can be effected as in pre-alveolar clefts.

GENERAL CONSIDERATIONS

Times to Operate.

There can be little argument against early closure of the lip cleft, and indeed few surgeons delay long in tackling this. It appears to me, however, unreasonable to fix any weight standard of fitness in this connection. Actual weight is of little importance, for children of widely different weights may be entirely fit subjects for operation. Nutritional progress is, in my opinion, the only sure criterion of fitness for operation, and I always leave it for my pædiatric colleagues to "say the word." On the other hand, it must be clearly understood that lip repair is never to be considered as urgency surgery. A child which can receive suitable attention can survive indefinitely with a widely open cleft lip. Every effort should be made to build up the infant's resistance before operation is attempted.

As already stated, it is my custom to operate on Group III lip clefts between the fourth and the eighth week. I am inclined to leave Group I cases, where there is no particular indication for early operation, until a little later, the time of operation being decided more by weather conditions than by age.

The use of mechanical appliances for temporarily filling the cleft and possibly facilitating feeding makes no appeal to me. Frail children from overcrowded homes are unsuitable for such treatment; an appliance intended to be a boon becomes a curse to patient and parent alike.

I operate on a cleft of the palate at or about one year of age. This time has been fixed because I feel that this is the earliest age at which

I can cope with the technical difficulties of the operation and the infant can survive the degree of surgical trauma which my manipulations involve. I am always anxious to have the repair completed before the child attempts to make serious use of his defective speech mechanism.

Theatre Lay-out.

I always operate on both lip and palate clefts from above the patient's head, which is thrown well back by placing a pillow under the shoulders. A low position of the operating table allows the surgeon to be seated and gives assistant and onlookers a good view of the operation field. The assistant stands on the right and manipulates the suction apparatus. The instrument Sister arranges her table close to the surgeon's right hand. Instruments are taken direct from, and returned to, this table by the surgeon, the Sister keeping them rinsed and in standardised order.

Illumination.

Any form of shadowless light is sufficient. When this is not available, headlights worn by surgeon and assistant have proved satisfactory.

Anæsthesia.

For the procedures described, intra-tracheal anæsthesia is essential, and I gladly acknowledge my indebtedness to Magill and his followers, whose developments have made this class of work possible.

Gag.

Experience of many kinds of gag left me dissatisfied in one way or another until Dott introduced the special Davis-pattern gag bearing his name. This, in a form only slightly modified to personal requirements, is made by A. Charles King & Co. It is used for all cleft palate cases. For the first operation on Group III cases, at which the anterior part of the palate cleft is treated at the same time as the lip repair, I employ the small size Lane's gag.

Instruments.

It is obvious that special instruments are required for the procedures here described, but no detailed list is given, since it must be equally obvious that different surgeons will find different instruments suitable for achieving the object of any particular manœuvre.

Team Work.

The surgeon who attempts cleft lip and palate surgery without the help of a well-organised team is courting disappointment. He may justifiably rank himself captain of this team but he should not consider himself as seriously more important than any one of its members. Intimate collaboration between surgeon and anæsthetist is of prime

importance. The anæsthetist makes the surgeon's work possible; the surgeon should see to it that he does nothing which will render the anæsthetist's work more difficult.

The theatre Sister, by failing to anticipate requirements, may be responsible for repeated delays which, in a relatively long and tiring operation, mount up and become an important factor to both patient and surgeon. *She should be "on her toes" the whole time.*

There is little room in or about an infant's mouth for two pairs of hands. The assistant does not get much of "a look in," but if he is quick and deft in his movements and, above all, if he has learnt the art —and it is an art—of using a suction end-piece to advantage, he makes a most important contribution to the operation.

Previous to, and after, the operation, the services of an expert pædiatrician are invaluable. Few surgeons can "spot," let alone treat, the disturbances peculiar to the small infant.

Only properly trained children's nurses know how to look after children, and I seldom persuade myself to undertake the treatment of a case unless expert nursing of this kind is available.

The later work on cleft lip and palate cases demands the services of an expert dental surgeon well versed in prosthetic work.

Records.

Good photographic records are invaluable, but very difficult to obtain unless the camera forms part of the operating theatre equipment as it does in Veau's service.

Personal notes of history, operation, and progress are essential if one's work is to indicate the relative value of different procedures and prove of use to others.

Operation notes should be written immediately after the operation, and graphic records should accompany these whenever possible. To help in standardising the latter I have had made a rubber stamp providing a dotted outline of the normal palate. The value of this is shown in some of the diagrams accompanying this section.

Warnings.

The infant's available airway is considerably diminished by closure of the palate cleft. A traction stitch should always be left in the tip of the tongue for use during the early stages of recovery from the anæsthetic.

If a palate suture line fails, never be in a hurry to re-operate. Discharge the child from hospital and wait for 3–6 months before attempting a secondary repair operation.

Be guarded in giving a prognosis when you are called upon to

operate on a palate which has already been operated on before. Scar tissue is unpleasant plastic material.

Never concentrate on closing small defects in the hard palate, forgetting, as so many surgeons do, the large defect behind the soft palate. Hard palate defects are readily filled by a dental plate. Remember that a long mobile soft palate in such a position as will provide oro-nasal sphincteric control should be the main object of all cleft palate surgery.

Summary.

The closure of unilateral and bilateral pre-alveolar clefts offers no serious difficulty.

The closure of complete unilateral clefts of lip, alveolus and palate is a difficult problem, and the repair of the lip cleft should always be combined with the repair of the anterior part of the hard palate cleft if an anatomically correct repair of the nostril floor is to be achieved.

Bilateral complete clefts of lip, alveolus and palate present still greater difficulties. Closure of one side of the lip cleft, together with the anterior part of the hard palate cleft of the same side, reduces the case to one of unilateral complete cleft, and this is repaired in similar manner as soon as the infant is fit for the further operation.

Successful repair in both these types reduces the palate problem to one similar to that presented by post-alveolar clefts.

Fig 2113.—This illustration is included to show the gross mutilation which may be produced by misguided secondary plastic work on the lip. Flaps have been taken from below the angles of the mouth and transferred to the upper lip, distorting the oral fissure yet contributing nothing of value to the upper lip.

Secondary Corrective Operations for Established Deformity in Cleft Lip and Palate Cases

Mention was made in the section on intra-buccal skin-grafting of the correction of the retroposed upper lip and nose (*see* fig. 2043). Reference has also been made to the Veau type of secondary correction of the deformity necessarily remaining after the closure of bilateral complete clefts in two stages.

Readers are referred for the discussion of these and other deformities about the lip and nose to an article by Gillies and Kilner published in *The Lancet* of December 24, 1932.

Figure 2113 is included to illustrate the mutilating effects produced by misguided secondary plastic work on an old bilateral complete cleft case.

CHAPTER X

Face-lifting Procedures

No work on plastic surgery would be complete without some reference to the so-called "face-lifting" procedures, for everyone practising this speciality is bound to encounter cases in which excessive loss of fat, due to illness or other causes, has produced a drooping, prematurely aged, and dejected appearance, that cannot be remedied by any non-operative cosmetic treatment. It is easy to argue that the operative treatment of such cases is a prostitution of the art of surgery; but there are many people to whom, in the keen competition of present-day existence, such stigmata mean much unnecessary suffering. In many instances earning capacity is directly related to appearance; actors and actresses, for instance, can seldom afford to look old. Men who have retired from public service, often after years spent in unfavourable climates, must supplement their pensions in order to give adequate support and education to their families, and have to seek work in the City, where first choice of employment is naturally given to those who still seem alert and vigorous. Shop assistants, too, find it difficult to obtain or retain employment if they show marked or unprepossessing signs of middle age. There are also other than economic reasons for these operations. There are, for example, numbers of unfortunate people who, though not in any way given to dissipation, present a dissipated appearance. One has only to listen to the pathetic stories told by people in such circumstances to realise how their lives are rendered miserable by their disfigurement, and to feel amply justified in carrying out the comparatively simple and certainly not dangerous procedures which will restore them their self-confidence and peace of mind.

There are other cases where the procedures are useful. Acne scarring of the face, X-ray effects sufficient to cause atrophy of the skin and wrinkling without any true dermatitis or necrosis, and depressed scars unsuitable for individual excision, may be greatly improved by stretching the skin in the same manner.

The usual excisions for this work are made at the junction of hairy scalp and non-hairy face skin, and it is from the latter that the necessary excisions are made. Numerous varieties of excisions from hairy scalp

apparently devised so that scars can be more completely hidden, have been described. In my opinion these have no place in the work. They result in the gradual pulling back of the hair-line and the sacrifice of hairy skin, and do not remove skin in the non-hairy regions where lack of tone and stretching is responsible for drooping and wrinkling.

Most operations of this kind are carried out under local anæsthesia. The injection of the solution obliterates normal contour. It is wise, therefore, to indicate the line of incision carefully by pen and ink before injecting.

It is dangerous to depict excision areas for this work, for no case should be commenced by outlining such areas. The main points of upward and backward pull are in the temporal and post-mastoid regions. Incisions are made here precisely in the hair-line. They are joined by an incision which passes down in the skin fold in front of the ear, around the attachment of the lobule, and upwards and backwards in the retro-auricular furrow (fig. 2114). The lower edge of this incision is raised, and undermining of the skin of the cheek and neck is carried out on a superficial plane for a greater or less extent according to the degree of facial or cervical prolapse. It is sound advice to suggest that this undermining should be accomplished by scraping, as it were, the deep surface of the skin. If this is done, bleeding is not severe and there will be no danger of damaging underlying nerves or other structures.

The skin flap thus raised is drawn upwards and backwards by tissue hooks or tenaculum forceps placed at its temporal and mastoid points, and trial is made of traction in different directions to find which gives the best results on the cheek and neck. Held in this position by an assistant, the flap is incised where it lies over the upper edge of the original incision at the two areas of main pull. A single suture of strong but fine silkworm-gut is inserted at each of these points. Once these are fixed it is easy to trim away the remaining redundant skin and complete the suture of the wounds.

Pull on the ear, and more particularly on the lobule, is to be stringently avoided. In most cases it will be found necessary to remove only a narrow strip of skin from that part of the flap which overlaps the incision in its course around the ear attachments.

The stitches employed are of the interrupted variety throughout for this allows of the early removal of those on which there is no tension Occasionally, in cases in which the cheek tissues are particularly heavy and pendulous, a long mattress suture of silkworm-gut is employed to take all strain from, and allow earlier removal of, the skin approximation sutures. This is passed through the scalp skin a short distance

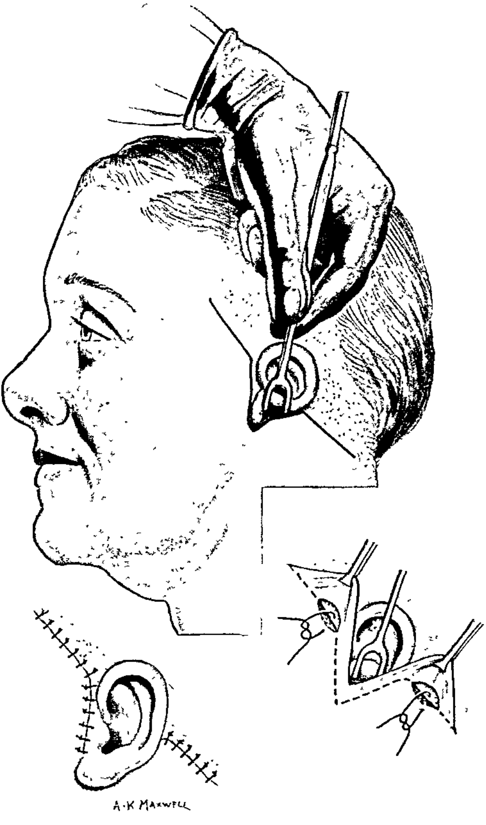

Fig. 2114.—THE TECHNIQUE OF FACE LIFTING.

above the incision in the temporal region, picks up the deep tissues of the cheek at the limit of skin undermining, and returns to emerge through the scalp skin adjacent to its point of entry where it is tied over a small button. This suture is retained until the other sutures have been removed.

Ordinarily no drainage need be provided but hæmatoma formation must be avoided at all costs. Definite bleeding points must be ligatured, but buried catgut in so superficial a position is liable to be troublesome, and as little as possible should be used. When oozing has been persistent during the operation it is wiser to insert drains of twisted silkworm-gut in the temporal and post-mastoid regions than to run the risk of having to open the wound later to evacuate blood clot. In most cases, carefully graduated pressure-dressings over the undermined areas, held firmly by crêpe bandages, are sufficient. Ice-bags and iced hammamelis lotion compresses are used freely to counteract congestion and bruising.

In some cases where there is much fulness of skin about the outer canthus of the eye, or where extensive upward pull produces some danger of dragging up the outer angle of the palpebral fissure or the outer end of the eyebrow, it is found useful to excise a small horizontal triangle of skin from the anterior edge of the wound at the level of the eye. This distributes the redundant skin more uniformly and leaves a scar which is difficult to trace after a very short time.

Working at the margin of the hairy scalp with hair exposed throughout the operation is unpleasant. Quite apart from the risk of infection the hair gets very much in the way when sutures are being inserted and tied. If a patient is not anxious to make an early reappearance in public, limited shaving makes the operation safer from the point of view of asepsis and is much easier. The hair-line should be clearly indicated either by preliminary marking or by leaving the actual marginal hairs cut short but not shaved. Where this is impracticable, it has been found helpful to "mat" the hairs together and smooth them away from the proposed incision line by a sterilised fixative cream made up from tragacanth.

Pre-auricular sutures are removed in three days lest they leave transverse markings. Cotton wool soaked in collodion is applied over the scar line in order to prevent early stretching or damage by the movements of the patient. Such protective dressing is particularly called for around the attachment of the ear lobule. Other sutures are removed, some in five and some in seven days.

Double Chin.

It is seldom justifiable to make a scar in the submental region for the removal of excessive fat deposit. Very occasionally, when a deep groove, in every way as disfiguring as a scar, is present, a curved transverse incision may be employed for this purpose. The vertical scar, still occasionally seen, is usually keloidal, contracted, and extremely disfiguring.

Eyelid Wrinkles : Upper Eyelids.

Skin folds in the upper eyelids, giving a heavy, sleepy appearance, are readily removed by simple crescentic excisions (fig. 2115). Local anæsthesia is employed, and care is taken to place the injections subcutaneously and to avoid injecting more solution than is necessary. The instillation of a few drops of butyn 2 per cent into the eye at intervals during the half-hour preceding the operation prevents involuntary movements and removes a great deal of the apprehension otherwise present. The excision is planned so that the resulting scar line

Fig. 2115.—Operation for excessive fulness of skin in upper eyelids.

will fall in the natural fold of the eyelid in the open position of the eye. It is sound practice to mark out the line of this fold before injecting, and to indicate the breadth of the strip which, by trial beforehand, it has been shown can be spared without distorting the eyelid margin. The skin crescent may be outlined by a scalpel and dissected away by scissors ; it may be pinched up in hæmostatic forceps and crushed in such a way as to make it stand up as a ridge which can then be readily removed by scissors ; or it may be both outlined and removed by sharp-pointed scissors. The first-mentioned method of removal is inclined to give incisions which go too deep and cause unnecessary bleeding ; the second is very simple but not sufficiently precise ; the third is probably the best method of the three.

Slight undermining of the edges of the wound, although not always essential, allows of more perfect skin apposition.

The subcuticular suture, always employed in this situation, prevents inversion of the edges and provides for easy removal. No knots are tied, and the suture ends are left long enough to be fixed down to the skin by small pieces of strapping. The sutures are removed in 48–72

hours. Iced Pond's Extract compresses are applied immediately after the operation and are renewed at frequent intervals to limit bruising and swelling.

The scar lines left by this operation are invariably good and, when correctly placed, become very difficult to find within a few weeks of the operation.

Lower Eyelids.

The removal of redundant skin from the lower eyelids is carried out in much the same manner as in the case of the upper eyelids, but here a much more careful judgment is required of the amount of skin which can be spared without producing eversion of the lid margin. This is particularly important in the "senile" atonic eyelid, where the removal of even a narrow strip of skin may drag the eyelid margin away from

FIG 2116.—OPERATION FOR EXCESSIVE FULNESS OF SKIN IN LOWER EYELIDS.

its normal contact with the globe and, apart altogether from appearance, may lead to troublesome epiphora.

The upper incision is placed very close to the eyelash margin; in this situation the resultant scar is well hidden. In order to prevent downward drag, where much skin appears to be redundant, and in order to tighten up generally the skin of the whole eyelid, it is usual to extend the excision downwards at its outer end, as in figure 2116. The skin below is undermined for a short distance. Closure of the lateral extension of the wound brings the edges of the remainder into juxtaposition, and here again a subcuticular suture is employed.

Eyelid Pouches.

There is a type of deformity which occurs in both upper and lower eyelids, but much more commonly in the latter, which no amount of skin removal will correct. It appears to be due to herniation of orbital fat into the tissues of the eyelid and takes the form of pouches. These disfiguring pouches may present themselves in quite young subjects.

Bourget and Passot of Paris have advised removal of such fatty herniæ through incisions in the conjunctival fornices, but such a procedure, fraught as it must be with danger of infection although producing no external scar, has never appeared to me to be justifiable. It would seem safer to gain access to such fatty collections by reflection

of skin and separation of the fibres of the orbicularis palpebrarum muscle. They are not difficult to isolate and are treated like herniæ elsewhere. The sac is cleared and opened and its edges are picked up in delicate forceps. The fatty contents are freed, clamped, ligatured, and removed. The sac is closed by catgut sutures and the muscle-fibres allowed to fall back into natural position.

It is usual to combine some skin removal with this procedure. Post-operative bruising and swelling are more severe than after skin removal alone, but the final result is usually very gratifying.

Forehead Wrinkles.

There is occasionally a clear indication for carrying out an excision from the forehead region—when frown lines or forehead wrinkles are disfiguring. In such cases the incision is again made at the junction of hairy and non-hairy skin. The lower edge of the wound is undermined to a suitable extent and the skin flap thus raised is reduced and adjusted in the manner described for temporal face-lifting. In order to eradicate forehead lines and lift drooping eyebrows, considerable undermining is required and bruising is usually severe.

Elliptical excisions placed laterally in the frontal hair-line are usually sufficient, if combined with extensive undermining, to eradicate vertical frown lines in the glabellar region. It seldom seems justifiable to produce a vertical scar in the latter region for the removal of redundant skin. The remarks already made in reference to submental incisions apply to this region also.

Operations for lengthening or shortening the palpebral fissure are relatively simple, but are considered quite unjustifiable except in the presence of real congenital deformity.

PART XX
OBSTETRIC SURGERY

by
ALECK W. BOURNE

OBSTETRIC SURGERY

Introduction

The greater our experience of the practice of surgery, the more we feel that the emphasis laid on difficulty moves from the execution of technique to the formation of a correct judgment on which our technique may be based. During the earlier years of practice it is probable that our chief interest lay in the mastery of the actual steps of technique, and in the acquisition of deftness and speed. We were fascinated by the anatomical scope offered by surgery and our interest was almost proportionate to the difficulty and danger of the more serious and radical operations. There was a thrill in seeking some deep and secret recess of the body. It was an adventure which tested courage, knowledge, skill and decision. The subsequent days or weeks maintained the interest as we watched, sometimes with alternating doubt and hope, the clean and quick recovery to convalescence. The patient presented an exercise in technique rather than a problem of pathology and treatment. The operation on the lesion was the chief interest, not the consideration of the best course which would ensure the recovery of the whole individual man.

When, therefore, we remember the fascination of our early experience in surgery it is not surprising that there was a temptation to exalt technique, and some of the more mechanically minded amongst us never progress beyond this stage.

But as time passed, the actual operation, while always able to hold our whole attention, gradually began to take second place in the general survey and treatment of any given patient. The growing familiarity with and facility of an oft-repeated performance allowed the much greater problem of judgment and pre-operative decision to assume the chief part. One of the characteristics of the mature and experienced surgeon is the greater importance which he attaches to the preparatory consideration of the diagnosis, and to the choice of the particular operation which will be most calculated to ensure the maximum benefit to the patient, both immediately and in the more distant future.

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OBSTETRIC SURGERY

Introduction

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based upon a true clinical insight. In no branch of surgery are these remarks better illustrated than in obstetrics. The actual performance of the operations is not, as a rule, difficult, though occasionally they may tax all our skill, but the decision of the right course of action in an obscure case must be a matter for the most careful thought. *An obstetric instinct and years of contact with patients in labour are* necessary before confidence arrives. Knowledge of *what* to do rather than knowledge of *how* to do it is a relatively late growth in the development of our surgical capacity, but it is of the greatest importance to our patients.

The majority of maternal deaths follow some form of interference, and we can say further that a substantial proportion of these are caused not so much by the technique employed, as by the unsound decision which preceded and prompted the operation. There are many reasons given to account for these errors of judgment; in many cases it is no more than a matter of saving time during a busy day's work which is the incentive to apply forceps. But one of the main underlying reasons is a fault in the teaching which tends to emphasise its surgical aspect and its mechanical problems, with the result that the attitude of mind is formed which finds a need for "helpful" interference at too early a stage in labour. Our teaching does not sufficiently stress the importance of *prognosis* during labour, which can only be based *upon a knowledge of function. Our emphasis is not placed upon the* physiology of uterine contraction and cervical dilatation but upon the mechanics of labour. The idea of disproportion of size of the head and pelvis dominates obstetric teaching. It is purely a mechanical conception, it is taught as such, and is therefore regarded as amenable only to a mechanical treatment. We do not teach sufficiently the phenomenon of the uterine contraction, the stimulating and inhibitory forces at work, the adaptability of the fœtal head, the existence of pelvic reserve, and lastly but not least the temperamental constitution of the individual woman. A better knowledge of these clinical details, and therefore of the prognosis of labour, would correct the widespread tendency to interfere during labour, and therefore reduce the rate of injury, hæmorrhage and sepsis.

It is the common *experience of obstetricians that the majority of* disasters follow manipulative interference rather than abstention therefrom. In other words we may say, "when in doubt, do nothing." Only the clearest indications for action should prompt an obstetric operation, and therefore my account of obstetric surgery will be concerned with discussion of methods and choice of procedure rather than with the steps of actual technique.

CHAPTER I

Induction of Labour

The artificial termination of pregnancy after viability is termed induction of labour. It is usually carried out before full term, in which case it is, strictly speaking, induction of premature labour, but sometimes it may be indicated after the calculated date of full term to prevent further post-maturity. The operation was first performed in 1756 by Denman in a case of contracted pelvis as an alternative to Cæsarean section and craniotomy, which carried, in those days, such a high mortality.

During recent years the operation has been practised very widely, not only for contracted pelvis but for many other indications which are thought to endanger the health or life of either mother or child. The comparative ease and safety of the methods in use are partly responsible for the prevalence of these operations, but it is doubtful if, in many cases, they are actually necessary. The widespread adoption of ante-natal care has provided opportunities for the discovery of many conditions in many patients as possible indications for induction of labour, but not all these conditions are real indications, and there is a tendency to see danger in allowing pregnancy to continue where none really exists. Particularly is this the case in so-called "disproportion", and in certain diseases associated with pregnancy.

It may be true that induction of labour is a comparatively safe operation, but it is by no means without risk. Professor Browne (*Lancet*, 1932, ii, 1) states that of the maternal deaths among booked cases at several obstetric hospitals one in twenty followed induction of labour, while at Queen Charlotte's Hospital the operation adds 0·23 per cent to the average death-rate of labour. It might be urged that if these patients had not been treated by induction of labour the death-rate from the condition for which induction was employed would have been greater, but as experience has shown us how many times it is performed for no adequate reason, it is probable that, in the aggregate, the results would be better if the operation were done with more circumspection.

This is not the occasion for criticising ante-natal care, but it is undeniable that it has been associated with a continued rise in maternal mortality and also with a wider interference with pregnancy, of which induction of labour is one feature. We will not fall into the simple syllogistic error of suggesting that the above reasoning shows that increasing prevalence of induction is a cause of an increasing maternal death-rate, but what may fairly be examined is the proposition that interference in pregnancy, including induction and Cæsarean section, does play a part in the rising maternal mortality. There are some well-defined conditions for which induction is a necessary form of treatment both for mother and child; there are others in which it is a matter of opinion. In the latter group fall the large number of cases of so-called disproportion. How far it is a good or necessary measure for this condition I shall discuss more fully in a later section. If the operation were entirely harmless the discussion would lose most of its point, but it has a definite risk not only of morbidity but of death. For example, during 1933, 256 cases of puerperal sepsis of all forms were admitted to the Isolation Block of Queen Charlotte's Hospital; of these 12 (4·7 per cent) cases had had labour induced by mechanical methods, and 5 patients (42 per cent) died. While other ætiological factors such as instrumental delivery were associated, and may have played a part, there are at least 3 of the 12 of whom no other factor is recorded. Further evidence of actual mortality has been supplied by Browne, who found that of 173 deaths collected from 8 maternity hospitals during the years 1927 to 1930 there were 8 due directly or indirectly to induction of labour. In these hospitals, which were high-grade, well-run institutions, about 1 in every 20 deaths followed mechanical induction. If these disasters followed a necessary operation for conditions which, if untreated by this method, carried a higher risk, there could be little criticism, but it is certain that large numbers of cases of "disproportion" had premature labour induced entirely unnecessarily.

There are other criticisms that can be laid against local interference as a method of induction of labour. The time elapsing between the introduction of the bougie and the onset of labour may be prolonged to such an extent that anxiety is felt lest the further retention of the bougie *in utero* may cause sepsis, while the tedium and uncertainty of the patient is sufficient to make her unwilling ever to have the operation repeated. It is true that the labour pains usually begin within three days, but quite commonly the delay may be as much as five days or more. If the insertion of a foreign body into the uterus or rupture of

the membranes fails after a reasonable time, the local condition is unfavourable for the operation of Cæsarean section, in view of the probability of infection. This difficulty may become serious in certain cases of disproportion where failure of induction of premature labour subsequently involves Cæsarean section.

But, having stated some serious disadvantages of this operation, it must be admitted that where it is truly indicated it may be a life-saving measure, both for the mother and the child. The conspicuous example of success is the treatment of toxæmia, whereby eclampsia and renal damage may be prevented.

During recent years increasing attention has been devoted to so-called "medical" induction which does not involve the mother in any risk. As we shall show later, it is largely unreliable as a means of inducing premature labour, though it is usually successful in initiating contractions at or after term.

The ideal method of induction, because of its ease and physiological sanction, would be some form of endocrine stimulation of the passive uterus. Our knowledge of the precision of action of the endocrine bodies, together with the absence of risk of infection, renders a method based on this principle highly attractive. The problem is wrapped up with that of the cause of the onset of labour and the maintenance of uterine contractions, about which we know little at present. Attempts to induce premature labour in women have not yet succeeded with sufficient uniformity to justify any clinical application. It is the obvious direction in which research on the clinical problem of induction of labour must be carried on.

INDICATIONS FOR THE INDUCTION OF LABOUR

TOXÆMIA OF PREGNANCY

When the group of diseases generally known as toxæmia are unrelieved by medical treatment, it is usually, if not always, imperative to terminate pregnancy. At what precise time during the course of any given toxæmia labour should be induced must depend upon many individual circumstances. Indeed, it may require the most experienced clinical judgment to arrive at a decision which, while safeguarding the interests of the mother, will also consider the chance of survival of the child. Whenever a pregnant woman develops albuminuria and a raised blood-pressure, the question of induction must arise, because it is seldom possible to cure, or even ameliorate beyond any threat of danger, the process of toxæmia. The problem is less *whether* induction shall be done, than *when* it should be done. A convenient way of

discussing the indications for the operation will be a description of the various *clinical types* with which we are confronted :

1. *The first group comprises all those cases which are first seen after the 36th week.* During the last four weeks of pregnancy the child's chances of survival are sufficiently good to save us from anxiety on its behalf, should induction be necessary. There need, therefore, be no desire to defer the operation, and so involve the mother in risk for the sake of the baby. In all cases of severe signs and symptoms, such as urine heavily loaded with albumen, high blood-pressure, vomiting, or marked œdema, labour should be induced at the earliest moment. The less serious cases should have a varying period of medical treatment, depending on the response of the physical signs, in order to detoxicate, as far as possible, before labour is induced ; but if there is the slightest sign of deterioration, or if any fresh symptom develops, labour must be induced at once. The general result of medical treatment of the milder cases is to produce a definite, though limited, improvement within 48 hours, but, after an initial fall in blood-pressure, reduction of albuminuria, and perhaps total disappearance of œdema, it is seldom that there is any further progress. The patient is still toxic, and probably still liable to eclampsia.

But even if we can say that the danger of eclampsia has been averted, we are still faced by the as yet unknown possibility of the danger of permanent damage to the kidney, which may be the result of continued albuminuria. The kidney which leaks albumen and discharges cellular casts is suffering from a functional strain. We have clinical evidence, obtained by following up the after-histories of eclamptic women, that the kidney may be impaired for many years. Should we not assume that, even though the sharpness of the strain in continued mild toxic albuminuria may not be so great as during the attack of eclampsia, yet the very chronicity of a stress of a milder degree may also impress a lasting strain on the kidney. I believe, therefore, that during the last four weeks it is a mistake to persist with medical treatment for more than a few days, even if improvement is quite definite. The very small group of patients who lose all their symptoms under the influence of medical treatment may be allowed to continue their pregnancy, but only under the strictest observation. If a woman has once had albuminuria she is liable to have a recurrence at any time until she is delivered. In general we may say that for toxæmia arising during the last four weeks, induction of labour will be necessary, either at once or after a brief period of detoxicating treatment.

2. *The second group includes those patients who become toxic before the 36th week.* The problem is now complicated by the fact that the child may die if delivered prematurely. Indeed, the risk of neo-natal death rises sharply for increasing prematurity before the 36th week. On the other hand, we must not forget that the fœtus *in utero* suffers a definite risk due to the influence of toxæmia. This is probably slight in cases of true toxæmia of pregnancy, for even in eclampsia there is a considerable survival of the children, but if a mistake has been made in the diagnosis, and instead of treating toxæmia we are actually dealing with chronic nephritis, the child is in grave danger of dying undelivered.

It is obvious that the earlier in pregnancy albuminuria first appears, the greater is the anxiety, partly because of the difficulty of maintaining the patient until the 36th week, and partly because the earlier it appears the more liable it is to be severe and progressive. For example, it is seldom possible to defer induction of labour if toxæmia first shows itself at or about the 30th week. The risk of persisting in medical treatment from the 30th to the 36th week is so great for the majority of such cases, that it is unjustifiable, and induction becomes imperative. Occasionally we meet with mild cases which react quickly to rest and depletion, but such are uncommon. The most difficult of all these problems is the patient who is a primigravida after some years of sterile married life. There can be few more anxious problems than this. We have seen the case of the childless woman, married for many years, who has had at least one operation and much other treatment for sterility. At long last she becomes pregnant. But about the 32nd week the blood-pressure rises and albumen appears. The usual medical treatment is successful for the first two days, and certainly reduces the symptoms, but they do not disappear and the patient is still obviously toxic. Meanwhile induction of labour will almost certainly sacrifice the child by prematurity, while continuance of pregnancy involves the mother in a steadily increasing risk. Each such problem must be considered on its individual merits, which are different in every case. There are many intangible factors, inherent in every family, which must be taken into consideration before the final decision on induction of labour can be made. In some cases these considerations will demand that the mother's endurance must be strained for the sake of the child, indeed she may easily decide the problem herself, while in other families the special effort must be devoted, by incubator and other unremitting care, to the struggle with prematurity.

The variation of special circumstances makes it impossible to give a detailed direction, but the writer feels that, where other things are

equal, the benefit of decision must always be given to the mother, not only if her life is threatened by the menace of eclampsia, but also because of the risk that she will carry the burden of nephritis for the rest of her life.

Where symptoms first appear at or after the 34th week, it is often possible to maintain the patient by careful treatment based upon daily watching of urine and blood-pressure until the 36th week, when labour can be induced, but if there is an increase in any of the original symptoms—which are usually albuminuria, raised tension, and œdema—or if any new symptom appears, such as vomiting, epigastric pain, or severe headache, then induction must be carried out at once. This rule is generally a safe one to follow in all cases of toxæmia. The "basal" state of the patient should be carefully noted after 48 hours of treatment, and further progress estimated from this datum line. We are fortunate in having two signs which are objective, and lend themselves to precise measurement. There are also other data such as the amount of urine, and its chemical constituents and blood chemistry which may also be taken into account, but we believe that it is unwise to be guided by chemical considerations alone. It is worth noting, in conclusion, that the patient's feeling of general well-being is not a guide to her clinical state. The majority of all women who show the three symptoms of raised tension, albuminuria, and œdema up to a moderate degree, never complain of any feelings of illness. In fact there may be a spurious sensation of increased vigour, due, possibly, to the rise in blood-pressure. This actually may cause difficulty, should the question of induction arise, in persuading the patient that the condition is sufficiently serious to demand termination of her pregnancy.

CONTRACTED PELVIS

We may say at the outset that induction of labour for contracted pelvis, or as it is often called "disproportion," is one of the chief controversial topics of obstetrics. The practice of different obstetricians varies between the two extreme poles of never inducing labour fo contracted pelvis, and of performing the operation for all cases whe the child can be delivered at or after the 36th week. Where opinio on lines of action for the same problem differ so markedly, we mu pause to think carefully. Either the results must be so nearly simila that either side must be equally correct, or else the practice of obstetri in this country must be such that neither school can be fully awa of the results of its own particular procedure.

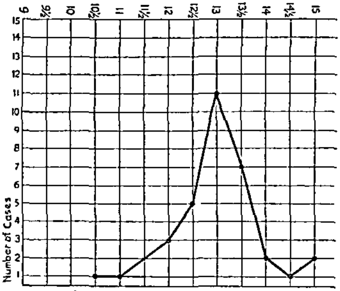
In the present section I shall attempt to discuss theoretical considera

tions, and produce figures which will provide evidence that induction should play only a minor part in the treatment of contracted pelvis.

In the first place let us attempt to define the clinical meaning of contracted pelvis and "disproportion." It is important to realise that the normal pelvis has a reserve space, or "room", beyond that required by the average child for safe passage. This is obvious if we place the fœtal skull in the dried pelvis in the flexed position. A certain amount of contraction, therefore, can occur without causing any embarrassment in labour provided, firstly, that it does no more than encroach on the reserve, and, secondly, that the child presents by the anterior well-flexed vertex. If, however, a pelvis is contracted to the limit of its reserve space, there would be real difficulty should any other abnormal condition co-exist, such as an occipito-posterior position, or a breech with extended legs. Manipulative treatment might be difficult, giving the impression that we were dealing with a case of disproportion in size between the fœtal skull and the pelvis. This view may be strengthened by noting that there is some reduction in pelvic measurements. Many such cases are labelled as cases of "disproportion," but actually it is not so much a case of lack of room in the pelvis, as of malpresentation of the head in a pelvis which has no reserve capacity to accommodate a mechanical abnormality. It is very true in obstetrics that a woman cannot carry two handicaps. She can manage delivery through a pelvis which has no reserve capacity, if the presentation be normal and the size of the child average, or an occipito-posterior presentation through a normal pelvis, but the two conditions together will cause trouble. The latter case is one of difficult labour, yet it is not really a matter of disproportion, though the suggestion may be strong. The same pelvis would pass the same baby in the flexed anterior position without difficulty. If, however, the pelvis is contracted beyond its reserve, then there will be trouble during the delivery of an average-sized baby, and here we have a true state of disproportion. It seems reasonable to say that if we can deliver the woman prematurely of a child a little smaller than the average we shall compensate for the contraction of the pelvis, and thereby enable her to deliver herself easily. There is no doubt that this can be done, and is done successfully, but we have to ask ourselves amongst other things, firstly, whether there is a greater risk either to mother or child if delivered by Cæsarean section, and secondly, whether induction at or after the 36th week can secure a child small enough to pass the brim and outlet of a pelvis which is truly and functionally contracted.

A study of the circumference of the heads of children delivered by

induction at or before the 37th week is instructive. A hundred consecutive cases have been taken from the records of a large maternity hospital. The results are as follows:



Size of circumference of Head at induction at 36 wks

CIRCUMFERENCE OF THE HEAD

Maturity 36th and 37th weeks

Circumference in inches	9	9½	10	10½	11	11½	12	12½	13	13½	14	14½	15
No. of cases	1	1	2	3	3	4	14	11	28	22	7	1	3

Of these cases, the three of 15 inches were of 36, 36, and 37 weeks respectively, while other inductions at 36 weeks produced children of the cephalic circumference shown in the table. Now the average circumference of the fœtal head at 40 weeks is 14 inches, which gives an average diameter of 4·45 inches, while the average circumference of the head delivered at 36 weeks is 13 inches, giving a diameter of 4·13 inches. There is therefore an average reduction of diameter in the region of 0·32 inch obtainable by induction of labour at 36 weeks. Not only is this reduction very small, but we find that of 33 fœtuses delivered at 36 weeks, 11 (or one-third) had a circumference of over 13 inches, and 10 below this figure. Two observations can be made from these figures: firstly, the wide variation in the size of the head at 36 weeks, i.e. between 10½ and 15 inches, and secondly, that induction performed 4 weeks before term, which is the maximum permissible time, will ensure an average reduction of one-third of an inch.

The argument, therefore, is that if a pelvis is sufficiently contracted to cause serious difficulty at term, it is unlikely that it will pass the child at 36 weeks sufficiently easily to give reasonable assurance of the easy delivery of a live child. The weights of the children delivered at 36 weeks are definitely less than those at term, but from the obstetric point of view it is not so much the weight of the child as the size of its head.

Much of the good reputation which has been claimed for induction for contracted pelvis is based upon the good results which have followed the operation performed for pelves which are not *functionally* contracted. But if an error has been made in the judgment of capacity for delivery, and a difficult forceps extraction becomes necessary for a fœtus of 36 weeks, it will, because of its greater fragility, suffer much greater risk from the stress of delivery than a full-term child which undergoes the same stress.

When considering the relative merits of induction and Cæsarean section in the treatment of disproportion, we must limit ourselves strictly to those cases of induction where there was no doubt that the pelvis was actually contracted. Hospital reports contain long lists of cases of disproportion where a scrutiny of the details shows that there was in fact no disproportion at all. For these patients induction was obviously unnecessary, even meddlesome, and the results should not figure in any statistical review. The mortality of Cæsarean section when undertaken before labour for contracted pelvis is about 1 per cent to 2 per cent, and for induction the added risk above that of normal labour is 0·23 per cent.

There is, therefore, a definite risk from induction for all cases done for "disproportion," as against a risk of about 1–2 per cent for the deliberate Cæsarean operation. But these figures are not a fair representation of the relative dangers. It is necessary to exclude all those cases of induction for so-called disproportion which did not actually exist, as proved by the conspicuously easy and short second stages of labour, described in various hospital reports. Where induction at 36 weeks is performed for true contracted pelvis, there is a considerable risk of a difficult delivery, and therefore a large enough series of these cases treated by induction of labour at the 36th week would probably show a greater mortality than the crude figures published by the hospitals.

Between the extreme views held by those who never induce labour for contracted pelvis and those who do it whenever possible, it is likely, on general principles, that there is a *via media*. The indications of the

operation depend, *inter alia*, upon the shape of the pelvis. The writer believes that for the true flat pelvis which holds the head above the brim and overlapping the symphysis it is bad treatment. The membranes will rupture early with the risk of prolapse of the cord, and the frail head of the premature fœtus will withstand the stress of moulding with little resistance. When the degree of flattening is sufficient to cause overlapping of the head at term, it will be probable that much moulding will be required to drive it through at or after 36 weeks. The problem of generally contracted pelvis is rather different. Here we find no disparity of "fit," for the shape of the brim is the same as that of the normal pelvis. During the last few weeks of pregnancy there will be an optimum moment at which the relation of the size of the head to the reduced but normally shaped brim will be the same as that of the normal head and pelvis at term. Labour at this moment should present the same risk therefore as at term, but it is, in fact, greater for the child because its softer head is less able to bear moulding. Nevertheless we believe that there are many women with mild degrees of general contraction who can safely deliver themselves of a child of about 6 lb., but who would have great trouble with one of 7½ or 8 lb. If induction is carried out for these patients, there is little or no risk of early rupture of the membranes or prolapse of the cord, as in the case of a flat pelvis.

We would sum up, therefore, by saying that, firstly, the greatest care should be taken to be sure that the pelvis really is contracted. As we have already said, very large numbers of women have labour induced for a disproportion which does not exist. The short period of the second stage of labour, the spontaneous delivery, and the unmoulded head are evidence of this contention. It is necessary to emphasise that the mere high position of the head above the brim does not by itself necessarily constitute evidence of contraction. There must be evidence derived from examination of the pelvis, not merely by measurement, which is misleading, but by careful internal exploration of the interior of the pelvic basin by the finger. Even difficulty in pushing a high head into the brim is not always a sign of disproportion. The difficulty may be due, not only to lack of skill in the manœuvre, but also to an unflexed state of the head. It is a common experience that at 36 weeks we may have decided to perform Cæsarean section for a case of high head which cannot be pushed down, but to our surprise, as term approaches, the head becomes fixed and engaged. This change may not become obvious until immediately before or even during labour.

Secondly, we may repeat that disproportion due to the large size

of the child's head where the pelvis is normal is extremely rare. But if the pelvic reserve is absent, naturally a large head will be disproportionate. In practice, however, the woman who has a generally contracted pelvis usually has a small baby, and therefore the large head is not often a cause of mechanical difficulty so long as it is well flexed and occipito-anterior.

True disproportion, or, as it is better termed, contracted pelvis, is far less common than many ante-natal workers think, but when it is discovered the treatment of choice is usually Cæsarean section. The fœtal results of induction of labour for contraction are given in the subjoined table, showing the risk to the child at the various stages of maternity.

Period of Gestation.	No. of Cases.	Fœtal and Neo-Natal Deaths.
40 weeks	120	19 (15·8 per cent)
39 „	52	6 (11·5 „)
38 „	132	9 (6·8 „)
37 „	47	5 (10·6 „)
36 „	59	9 (15·3 „)
35 „	4	2 (50·0 „)
34 „	12	5 (41·6 „)
32 „	4	2 (50·0 „)
30 „	2	0
28 „	1	0
24 „	1	1 (100·0 „)

The general results at Queen Charlotte's Hospital between the years 1908 to 1917 were that of 434 cases the maternal mortality was 0·23 per cent, of 340 fœtuses delivered spontaneously 10·8 per cent died, and of 94 delivered by forceps 17 per cent died.

ANTE-PARTUM HÆMORRHAGE

All cases of placenta prævia should have pregnancy terminated as soon as the diagnosis is clear. It may be a harsh decision where the mother has not quite reached 36 weeks, and the first and only bleeding has been unimportant. But it is certain that if induction is postponed some patient will, sooner or later, suffer the sudden fatal hæmorrhage. It is useless to expect that rest in bed or any form of treatment can exert the slightest influence, as the bleeding nearly always occurs while the woman is asleep in bed.

The case of accidental hæmorrhage (abruptio placentæ) is rather different. Here the underlying condition is often toxæmia, which, if treated, will prevent further bleeding. Other patients have only small

trifling hæmorrhages which, though they may persist for some days, are seldom a cause of danger, and are readily amenable to treatment by rest and detoxicating measures. There are some severe cases of accidental hæmorrhage, again usually due to toxæmia, which must be treated by methods which will have, as their immediate object, the relief of shock, the arrest of hæmorrhage, and, incidentally, induction of labour. It should be clearly understood that neither for placenta prævia nor for grave accidental hæmorrhage should labour be induced as a primary method of treating hæmorrhage. Though it is true that the result of treatment will ultimately be the termination of pregnancy, yet the measures adopted are chosen from the point of view of arrest of bleeding and not as the quickest method of inducing labour. The onset of labour is an incidental and, indeed, necessary result, but it is not the primary consideration.

THREATENED DEATH OF THE FŒTUS

Occasionally a woman may repeatedly give birth to dead children at or about term for no apparent reason. The most careful examination for nephritis, syphilis, or deformities, fails to find any evidence of these conditions. The mother reports cessation of movements during the last 2 weeks, and a few days later a dead baby is born. The risk of yet another still birth may sometimes be overcome by induction of labour at the 36th week, or at a time just before previous deaths have occurred. This is not always successful, but there is a better chance of obtaining a live baby than by allowing pregnancy to go to term.

POST-MATURITY

The calculated date of labour obviously gives only an approximate idea of the real date of full term. Our knowledge of the time of ovulation makes it clear that the end of the 40th week may follow as much as 2 weeks after the calculated date of term, and therefore it is not possible to diagnose post-maturity until at least 2 weeks have passed beyond the woman's "date." Further, there is always the possibility that she has made a mistake of even a month in the date of the last menstruation. It is probable that real post-maturity is uncommon, and that it is not enough that the calculated date has been passed, to diagnose post-maturity. Until 2 weeks have passed, therefore, there is no real indication for interference. Occasionally, however, special circumstances of the individual case may warrant induction of labour. For example, the woman may be of that nervous or impatient temperament which frets at the delay to such an extent that induction must

be performed. Or there may be circumstances of nothing more than convenience which, in an individual case, may justify the operation. In general, however, we may say that during the first fortnight after the calculated date nothing should be done so long as the general and local conditions are satisfactory. Provided the woman is well, and the head either engaged or fairly easily pushed down into a normal pelvis, there need be no anxiety during the first 2 weeks. After this, the question of post-maturity may actually arise. Should the correctness of the date of expectation be beyond a doubt, it is probable that the third week past " term " represents the first week of post-maturity. A fat,

CASES OF INDUCTION OF LABOUR FOR ALLEGED POST-MATURITY

Weight.	Circumference of head in inches	Duration of second stage.
10 10	15	1.35′
9 3	15	10′
7 5	14	40′
6 10	15	1.12′
8 4	15	37′
7 11	14½	50′
7 2	13½	1.10′
8.12	14½	30′
6 5	14½	55′
8 8	14	1 0
6.3	14½	20′
10 4	15½	10′
6 4	14½	1 30′
6 9	14	15′
9 4	14½	1 0
8 8	15	2.0
7.7	?	1.0
6 0	14	20′

sedentary, lazy woman is liable to go beyond her real term—in such a case a short period of post-maturity may be expected. Secondly, the size of the child and its head should be noted. Whereas it is impossible to estimate the weight of the child accurately before delivery, yet extremes of size are obvious. If the uterus is clearly small for the apparent date, or if the palpable diameter of the head is not larger than normal, post-maturity does not exist or, shall we say, even though the scheduled number of weeks have been passed, the maturity of the child's development is not too advanced for its safe delivery. But there are some patients in whom the abdomen is distended by a large, tense uterus, containing not an excess of fluid but an undeniably large baby.

The head also feels wide, large and hard. We feel that for this woman labour should be induced at the end of 2 weeks, if not before. As the method of choice in these cases is by castor oil and other drugs, there is not the same objection to induction as when bougies or tubes are inserted into the uterus.

Evidence of the frequent incorrectness of the diagnosis of post-maturity is supplied by the table (on preceding page) of consecutive cases of induction for "post-maturity", taken from the records of a maternity hospital for 1933 and 1932. The length of all the pregnancies is described as "40" weeks. It will be noted that only 7 out of 11 babies weighed $8\frac{1}{2}$ lb. or more, and only two could be described as very heavy children. The circumference of the head was unduly large in only one child ($15\frac{1}{2}$ inches), and in this labour the second stage lasted only ten minutes, while in the majority this measurement was either within or below normal limits. The times of the second stage of labour, all spontaneous, are further indications of the absence of the difficulty which was anticipated by those who induced labour.

ASSOCIATED DISEASES

It is a generally true principle that when pregnancy complicates, or is associated with, a pre-existing disease or one developing during the course of pregnancy, it is usually wise to treat the disease and leave the pregnancy alone. There are, however, some well-defined exceptions, chief amongst which are chronic nephritis, certain cases of cardiac disease, diabetes, depression, goitre, and many other conditions represented by an occasional example. The individual circumstances of almost every disease may specially conspire to render induction advisable in the exceptional case, but nevertheless it is a general rule that, except for nephritis and cardiac disease, induction is seldom required. Indeed it is true that in many cases not only should induction not be performed, but every effort made to prevent the onset of premature labour. This is generally true of all acute infections such as influenza and the great majority of all cases of pyelitis. Some diseases may be actually "improved" by pregnancy, an example of which is hypochlorhydria, while a notable exception is phthisis, where not only no good but actual harm may be caused by induction after the third month.

In chronic nephritis, however, the condition is definitely exacerbated by pregnancy, not only for the time being, but permanently. The mother will suffer by the continuation of her pregnancy and there will be a large risk of the death of the fœtus *in utero*, at a time depending upon the severity of the disease. Induction, therefore,

though terminating pregnancy before the child has a chance of survival, does not often deprive her of a child which she would have had if induction had been withheld. It is probably true that every case of chronic nephritis should have labour induced during the last 4 weeks, not only for the sake of the mother, but also to save the baby from probable death *in utero*. Before the 36th week there may be some effort made to treat by medical measures until this date has been reached, but, generally speaking, we should say that there is far less latitude for temporising than in the case of true toxic albuminuria. Opinions differ in respect of heart disease. The problem is not quite the same as in induction of abortion. When the child has passed the period of viability, every effort should be made by rest, digitalis, and symptomatic treatment to nurse the heart into some degree of compensated efficiency. It may be that by reason of hydramnios or other obstetric conditions induction would be advisable, but, as a general rule, it is better to allow pregnancy to proceed to term. There are, however, exceptions. For example, a multipara with a history of previous easy labours, who is finding the last month a great burden, even though in bed, may have the membranes ruptured. This, provided other details are normal, will ensure that she has a quick and easy labour. In no circumstances should labour be induced during any acute attack of heart failure, and in all cases only after some days of treatment in bed by digitalis. If possible all symptoms of failure, such as irregularity, œdema, albuminuria, and cardiac pain, should have disappeared.

With regard to all other associated diseases every case should be judged individually. Two questions must be asked: First, is the progress of the disease advancing by reason of the pregnant state? Second, will the operation of induction of labour actually relieve the strain or will it not only add to the stress but also fail to relieve even though pregnancy be shortened?

INDUCTION OF LABOUR

Methods

1. *Induction by Drugs.*

The desire to avoid local interference, with its obvious disadvantages, has led to many attempts to provoke uterine action by drugs. Of these castor oil, quinine, and pituitary extract, together with enemata and hot baths, have been used in varying methods and combinations. It is probable that quinine has a bad effect on the fœtus—evidence has been brought forward to show this—whereas its effect on uterine contraction is to render it uneven and not stronger. It should be

discontinued. Both castor oil and pituitary extract will frequently start contractions at or near to term, and especially if the date of term has been passed, but unfortunately this method is most unreliable as a means of inducing labour at or before the 38th week. Moreover, it is somewhat exhausting for the woman, especially when it has to be repeated. In the writer's opinion it is of little value except for post-maturity, or as a means of starting labour at term for the sake of convenience. There are some cases of toxæmia which may be so treated, but, as a rule, a better method is rupture of the membranes.

A specimen of the time-table of the so-called drug induction is as follows:

8.0 a.m.	Castor oil	1½ ounces.
12.0 noon.	Simple enema.	
2.0 p.m.	Pituitary extract	5 units.
3.0 p.m.	,, ,,	5 ,,
4.0 p.m.	,, ,,	5 ,,

The injections of pituitary extract may be repeated each hour without danger, but if no contractions appear in response to these injections, it is useless to repeat them. Occasionally, a few slight pains will follow about ten minutes after each injection, only to die away in half an hour. Should this occur, it is worth while repeating the whole treatment in 48 hours. The results are as follows:

Of 50 cases for whom this method was used at or before the 38th week, it was successful in provoking contractions in 34 (or 68 per cent). When the method is successful, pains usually begin during the course of treatment, or, if not then, within a few hours after the last injection. In some clinics thymophysin is used instead of pituitary or pitocin, but there seems to be little difference between the two preparations.

2. *Rupture of the Membranes.*

This is probably the oldest method which has been employed. During recent years it has been revived as an alternative to the use of bougies or stomach tube, and favourable reports have been published. There has been a theoretical prejudice against artificial rupture of the membranes because of the fear of depriving the cervix of its natural dilator, and so delaying the first stage of labour. If delay occurs, other dangers also arise such as prolapse of the cord, pressure on the fœtus, and infection. It is a fact, however, that nearly all multiparæ and very many primigravidæ whose membranes rupture at the beginning of labour not only have no delay, but may even have a quicker labour than normally.

But though for certain cases it is a successful and generally satisfactory method, yet it is important that the cases should be carefully chosen. If the head is engaged in a normal, flexed, anterior position, and especially if the woman is a multipara, rupture of the membranes is the easiest, quickest, and most certain method of inducing premature labour. The cases which present these favourable conditions and which require induction are chiefly those of toxæmia, and, in addition, toxæmia is sometimes complicated by hydramnios, for which rupture of the membranes is good treatment. The escape of excessive fluid frequently has a beneficial effect on toxæmia, apart from any other treatment, which is a further reason for rupture of the membranes.

But for disproportion or contracted pelvis the conditions are very different. Here the head is high, and rupture of the membranes before labour will leave no dilating surface to occupy the cervix. This alone tends to delay the onset of useful contractions. The high head will also not form the normal barrier to prolapse of the cord, or to the escape of all the liquor amnii. The uterus is then " dry," and the baby is grasped dangerously by the contracting fundus. Rupture of the membranes is a useful method for post-maturity and for most cases of associated diseases for which labour must be induced if drugs have failed. This minor operation may be difficult unless the patient is in a convenient position, often under an anæsthetic, and there is a good light and suitable instruments. In order to be sure of cleanliness it is necessary to operate by sight, through a speculum. This can usually be done in multiparæ without an anæsthetic, but primigravidæ may be too intolerant of the discomfort.

The procedure is as follows: The woman may have to be anæsthetised. She is placed in the lithotomy position or on her left side, according to the custom of the operator. The vagina is swabbed with iodine, or perhaps better with dry sterile gauze. The cervix is lightly held by vulsella, and a pair of toothed forceps or vulsella is passed through the os, and opened and closed gently on the fœtal head. This usually means that the membranes will be caught and broken, but it may be necessary to make several attempts before they can be ruptured. It is useless to push in a blunt instrument like a sound, for the amnion is usually too tough to yield. A primigravida may require a little dilatation of the cervix before toothed forceps can be introduced. After the escape of liquor shows that the membranes have been punctured, the head should be held up off the os by the finger to allow the escape of a portion of the liquor. Unless this is done, the liquor may dribble away so slowly that the uterine contents are not reduced quickly

enough to stimulate the rapid onset of pains. The results of this method are as follows:

Parity.	Average time *before* onset of pain.	Extremes of *times before* onset of pain.		Average duration *of* 1st Stage.	*Shortest* 1st Stage.	*Longest* 1st Stage.	Average duration *of* 2nd Stage.
		Long.	Short.				
26 Primip.	14 h. 25′	88 h.	1 h.	16 h. 13′	1 h. 20′	72 h.	3 h. 8′
21 Multip.	12 h. 55′	66 h.	½ h.	5 h. 28′	1 h. 10′	23 h.	30′

There was no maternal mortality.

Still births and neo-natal deaths—20 per cent.

Inductions were performed for disproportion, post-maturity, toxæmia, pyelitis, hydramnios (1 case), and cardiac disease (1 case), and no other method was used for this series but rupture of the membranes.

A glance at the table shows a reasonable time before onset of pains, and a first stage not differing from that of normal labour. The long extremes of times in both cases were exceptional. The fœtal mortality was high and was associated with the following conditions:

Albuminuria	9
Dead fœtus before labour	3
Eclampsia	2
Post-maturity	1
Hydramnios	1
Anencephaly	1
Graves' disease	1
Unstated	2

3. *Bougies (Krause's method).*

The principle of this method is the introduction of a foreign body into the uterus whereby irritation will set up contractions. For many *years this has been the method of election in all cases requiring induc*tion, but recently it has to some extent been supplanted, especially in hospitals, by drugs or rupture of the membranes. It is chiefly useful where it is desired to retain the membranes intact, as for contracted pelvis, or where drugs have failed, or before the 38th week when drugs are not likely to produce labour in more than 68 per cent of cases. It is carried out as follows: In order to ensure asepsis, an anæsthetic is usually necessary, and, as before, the patient is placed in the lithotomy position and disinfected. The cervix is lightly held by vulsella, and sometimes requires dilatation. If possible the finger is passed through the os in order to separate the membranes around the os. This may have some effect in stimulating the onset of pains. Four

bougies of gum elastic are now carefully passed, one by one, through the os until their heels are well within the uterus. The vault of the vagina is then lightly packed with gauze soaked in acriflavine. Bougies should be sterilised by keeping them in a long glass tube saturated with formalin vapour. Special glass containers are made for this purpose, or, if not available, the bougies should have been kept overnight in a solution of biniodide of mercury, 1 in 500. Heat renders them too soft for use. Certain difficulties are occasionally encountered: resistance to the passage of the bougie may be felt after it has passed two or three inches within the os. This is almost always due to its impinging on the edge of the placenta. No further force should be used, but other bougies inserted in different directions. Occasionally a brisk hæmorrhage occurs as the bougie is being passed. This indicates that it has passed under the placenta. It should be removed at once, the membranes ruptured, and the vault of the vagina packed unless the bleeding stops quickly. It usually ceases almost at once, and no serious results ever follow. There is very little danger of sepsis if the bougies have been carefully sterilised, if they have been passed straight into the cervix without touching the vagina, and if the cervix is uninfected.

The chief disadvantage of this method, apart from the fact of local interference, is the uncertainty of the time of onset of contractions. Pains usually begin within three days, and often within twenty-four hours if the patient is near to term, but it sometimes happens that five days have passed and still labour has not begun. On the fourth day it is well to give a large dose of castor oil, and on the fifth day to remove the bougies and rupture the membranes. A further disadvantage of the method when it fails after having been done for contracted pelvis is that the presence of the bougies within the uterus for five days renders Cæsarean section an unsafe operation because of the danger of infection.

4. *The Hydrostatic Bag.*

Many varieties of water-filled rubber bags have been invented for introduction through the os into the lower segment. The best known are those of de Ribes and Horrocks, but there are others commonly used which are simple rubber balls, filled through a long tube, and containing about 4 or 6 ounces. The de Ribes bag, made of silk and rubber and shaped to occupy the lower segment, contains 17 ounces. It is introduced by a special forceps-holder through the cervix, which, after the membranes have been ruptured, must be dilated to allow two fingers to pass. It is then slowly filled by a Higginson syringe. It displaces the presenting part and lies accurately in the lower segment. The

presence of so large a foreign body within the lower segment quickly stimulates the onset of contractions and dilatation. The de Ribes bag is seldom used for inducing labour, except for certain cases of placenta prævia, but even for this it has been largely given up in recent years.

There is less objection to the use of the small round bag, which is somewhat smaller than a tennis ball. A good form of this is the ball pessary. The os need not be larger than will admit one finger, the membranes need not be ruptured, and it does not displace the presenting part so greatly as the de Ribes bag. It is quite certain in its effect, for the onset of labour is rarely delayed beyond 24 hours.

There are, however, various objections to the use of bags. They perish easily and are therefore liable to leak. This, apart from destroying the essential value of the apparatus, involves a danger of sepsis. The introduction of the bag always requires an anæsthetic and some dilatation of the cervix. It is possible for the bag to be displaced to one side, allowing the head to descend and press upon the neck of the bag, thus preventing it from being expelled, while the presence of the bag also prevents the head from dilating the os. A form of obstructed labour can thus arise. The only advantage of the de Ribes bag, apart from its use for placenta prævia, is for those cases of disproportion where the head is high and cannot come down to dilate the os until it has been well moulded. This bag will dilate the os to a diameter of 3 inches during its expulsion, and so prepare the way for the descent of the head.

On the whole, bags are not used much for induction of labour. Simpler methods should be employed.

5. *Endocrine methods.*

Experiments on animals with the ovarian hormones raised the hope that it would be possible to stimulate the onset of labour by giving injections of œstrin. The earlier experiments all failed because the dose was too small. But doses up to one million units have failed in the writer's hands, even when combined with pituitary extract. It is possible that still larger doses may succeed, but though there is a promise in this direction there is no certain evidence that human premature labour can be induced by œstrin.

CHAPTER II

VERSION

VERSION is probably one of the oldest of all obstetric manipulations. It is concerned with changing the presentation of the fœtus, either because its delivery in the unaltered position would be difficult, or because the new position would form a useful treatment for placenta prævia, flat pelvis and other conditions. The varieties of the manœuvre are described as external, bi-polar, and internal.

EXTERNAL VERSION

Before or at the onset of labour the child may be turned by manipulation of its head and breech, applied through the abdominal wall. It is nearly always done to change a breech presentation into a vertex, but occasionally for placenta prævia to produce a breech presentation, preparatory to pulling down a leg. For breech presentation it is the usually accepted treatment if the presentation is discovered before the 38th week, but after this date it is often impossible owing to lack of easy mobility of the child. The difficulties attending successful version are due to extended legs, relative lack of liquor amnii, twins, and tense uterine or abdominal walls. Sometimes an anæsthetic will enable it to be carried out successfully by abolishing the tone of the abdominal wall. Engagement of the breech within the pelvis, usually associated with extended legs, is a frequent cause of difficulty, though this can often be overcome by using the Trendelenburg position and an anæsthetic. The rate of success in all attempts is as follows:

Total No. of cases.	Failure.	Number turned under anæsthesia	Spontaneous version before term, after failure	Still birth following failure of version
233	42 (18%)	55 (23%)	10 (out of 42) (24%)	11 (out of 42) (26%)

These figures show a higher rate of success than is usual, and probably a higher tendency towards the use of anæsthetics than in most clinics. It will also be noted that, even when external version fails, about a quarter of the cases undergo spontaneous version. Whether this would have happened in any case, or whether it is a result of the

disturbance of the fœtus caused by the efforts to turn, cannot be stated, but it may be assumed that, even if there is little prospect of turning the child, it is worth while making the attempt, for even if it fails, spontaneous version can occur during the following few days. The *raison d'être* of the operation is based upon the high mortality of children delivered by the breech. In some clinics this is as high as from 20 to 30 per cent. The mortality of children delivered by the vertex is much lower, and hence the advisability of changing the presentation wherever possible. But it must not be assumed that the fœtal death-rate of the vertex deliveries after version is identical with that of normal vertex. Figures published by Wrigley (*B.M.J.*, May, 1934, 893) state that, of 45 patients for whom version was performed under anæsthesia, 10 had still-born children, usually macerated. That is, the fœtal mortality of vertex delivery after successful version under anæsthesia was as high as 21 per cent. Of 19 cases in which version failed, all the children were born alive! There are definite dangers attending external version when it is performed without care. Too forcible manipulations are liable to separate the placenta, or even to damage the uterine wall. The fœtus is always distressed to some extent during the manœuvre, as can be shown by the state of the fœtal heart both before and after. It is probable that too rough or prolonged efforts may kill the fœtus, or a true knot may be formed in the cord. A safeguard against too forcible handling of the uterus is the woman's sensation of pain, which is not available if the patient is anæsthetised.

In addition to breech presentations, all shoulder presentations should be turned to the vertex position wherever possible.

METHOD

The time of election is at or about the 36th week. Before this time the fœtus is liable to undergo spontaneous version, whereas afterwards the relative size of the child to the amount of liquor amnii increases sufficiently to destroy its mobility. The woman is best placed in a slight Trendelenburg position, and according to the opinion of many it is an advantage to anæsthetise her. The writer's own belief is that it is safer not to give an anæsthetic. The abdomen is examined to find the lie of the child, as it is important to turn the child in the direction in which its face is looking in order to keep the fœtus flexed. The operator stands on the side on which is the child's back, and applies both hands to the breech in an attempt to lift it out of the brim on to the iliac fossa (fig. 2117). This may be impossible, and if so, then no further efforts to turn it will succeed. When the breech has been brought on to

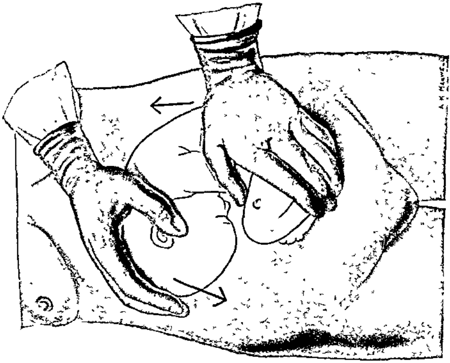


Fig. 2118.—The second step in external version. Having "scooped" the breech into the iliac fossa, the right hand is removed to push the head down from the fundus, while the left hand holds the breech from slipping back into the pelvis.

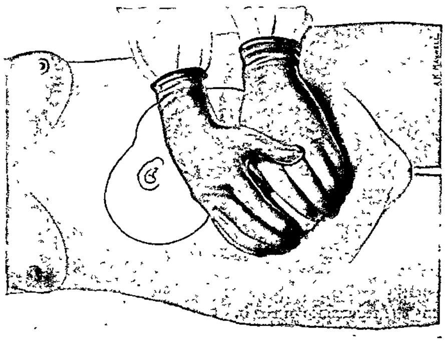


Fig. 2117.—The first step in external version. The operator, standing on the same side of the patient as the child's back, applies both hands to the breech in order to "scoop" it out of the brim into the iliac fossa.

the iliac fossa it is held there by one hand, while the other hand presses down the head to bring it towards the brim (fig. 2118). At the same time the breech is lifted up towards the fundus (fig. 2119). The movements imparted to the fœtus should be more those of intermittent than of continued pressure. It is often possible to bring the child into the

transverse position, but impossible to bring the head down on to the brim.

This may be due to extended legs or occasionally to twins. After the version has been completed, a tight binder is applied and a folded towel placed in each iliac fossa to maintain the head over the brim for 24 hours. In most cases the breech position will not recur, but if after a few days a further examination finds the head in the fundus, a flat pelvis or placenta prævia should be suspected unless hydramnios or

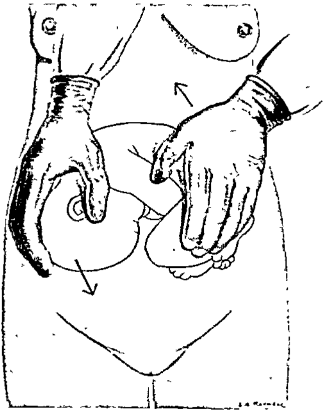


Fig. 2119.—External version. As the right hand pushes the head down towards the brim, the left hand is lifting the breech up to the fundus. The final stage is reached as the head rests over the brim, and the breech is in the fundus.

undue prematurity is sufficient to render the child unusually mobile. Recurrence often follows a version which has been very recently performed, but when there has been much difficulty the vertex position is permanent. If recurrence of the breech position should follow, it is well to wait a few days and then to turn the fœtus again.

BI-POLAR VERSION

After labour has begun it is usually impossible to perform external version because of the irritability of the uterine wall, but it is still possible in certain cases to turn the child before full dilatation, provided the os will admit two fingers. It is always done to convert a cephalic

presentation into a breech, generally with the object of bringing down a leg. The chief indications are selected cases of placenta prævia, prolapse of the cord and face, and brow or shoulder presentations. When first introduced by Braxton Hicks it was a considerable addition to the manipulative treatment of obstetrics, especially for placenta prævia, and, in those days, for flat pelvis. In recent years, however, it has been less used, chiefly because many of these abnormalities are treated by Cæsarean section or by other methods. There is no doubt, however, that it is a very valuable method for dealing with many cases of placenta prævia, and it is probable that in time it will again figure in the reports of maternity hospitals. The statistical results for the mother are good, but for the child they are not so promising, chiefly because it is usually undertaken for quite premature children whose chance of life is in any case slender. Despite the increasing use of Cæsarean section and its *prima facie* appeal to the obstetrician, there is a definite field for the practice of bi-polar version in the treatment of placenta prævia. A multipara, first seen when the os will admit two fingers, with a placenta felt at its margin or even completely covering it, and of maturity of 36 weeks or less, is usually a suitable case for treatment by bi-polar version. If such a patient, who has already suffered sufficient hæmorrhage to produce an obvious anæmia, is found in circumstances where laparotomy would be unwise, or transport difficult, bi-polar version is by far the safest treatment. We would go further and say that the graver the anæmia, the wiser it is to perform a manœuvre which will certainly arrest further bleeding and involve the least shock. The real disadvantage of the method is actually its difficulty. In some cases where the os easily admits two fingers and the child is small and mobile it is a simple manœuvre, but it is often difficult enough to occupy several minutes, and so provoke further bleeding from the lower segment. This is the crux of the difficulty. The disturbance of the os, placenta and lower segment will cause additional bleeding, and if version requires more than a few minutes a fatal hæmorrhage may occur. A considerable advantage of the method is that when the leg has been brought down there is almost no risk of further hæmorrhage. It is impossible or unsuitable before the os will admit two fingers or when it is large enough to admit the whole hand for internal version, also if the child is large enough (or the liquor has escaped) to render it immobile. Free mobility is a necessary condition for performing the method safely and expeditiously.

Other indications for which it might be advantageous to convert a vertex to a breech presentation when the os will only admit two

fingers are certain cases of face and brow presentations, prolapse of the cord, and flat pelvis. As flat pelvis may be found associated with these presentations as a cause thereof, it is important, before version is contemplated, to be sure that the degree of contraction is not so great as to make safe delivery of the after-coming head impossible. *Version* for flat pelvis, apart from associated malpresentation, was often employed formerly as a sound method of treatment, and many of the more senior practitioners of to-day still favour it. Provided that the true conjugate is not too seriously contracted, say, not below 3½ inches, there is a mechanical advantage in extracting the after-coming as opposed to the fore-coming head because of the narrower wedge offered by the after-coming head to the pelvic brim. Where brow presentation, uncomplicated by flat pelvis, is first seen after the woman has been in labour long enough to dilate the os to the size of two fingers, bi-polar version may, by abolishing an obstructing position of the head, be the *least risky method of delivery. Face presentation should be delivered* as such, provided that the pelvis is normal, but if, as often happens, there is a mild degree of flat pelvis, version may be considered as the best method of overcoming both the malpresentation and the pelvic contraction. The ideal combination of circumstances as an indication for bi-polar version must, however, be very uncommon in these days of ante-natal examination and Cæsarean section.

The case of prolapse of the cord is rather different. If the pelvis is normal or mildly flat, and the cord cannot be successfully pushed up, the tendency for the cord to prolapse can be prevented by turning the child and pulling a leg through the as yet imperfectly dilated os. Such treatment is specially indicated where the pelvis and the child are of normal size and the woman is a multipara. The point against version is that we are thereby producing a presentation which carries a high degree of risk for the child, but if the cord cannot be maintained above the presenting part, the child will certainly be lost unless something drastic is done. In general, it may be said that bi-polar version competes with Cæsarean section as a method of treatment, but because of the extended scope of this operation by the technique of the lower segment incision, bi-polar version has been less and less employed during recent years. There is no doubt, however, that the stage of labour at which bi-polar version may be called for is often one carrying much risk if Cæsarean section is performed, and version is undoubtedly the safer method. This is particularly the case in placenta prævia where the placenta is marginal, and the baby is premature and small. This may also apply to some cases of prolapse of the cord where, other things

being normal, the child is already in a condition of distress. The chance of delivering a live child, already shocked or distressed, by Cæsarean section is small, whereas, though version may add something to the shock, yet the rest *in utero* which follows version with the cord replaced will allow sufficient recovery before the stress of delivery is at hand. If the child is in good condition and the membranes have not ruptured for more than two hours, and if there has been nothing but the minimum and cleanest vaginal examination, then Cæsarean section is, on the whole, the better treatment, but if the child's chances are poor, and if the mother is a case of "suspect sepsis," then, as a rule, bi-polar version is the better method for the indications already mentioned.

METHOD

Certain conditions of labour must be present for the successful performance of bi-polar version. For example, the os must be large enough to admit at least two fingers, and the child must be freely movable. If the membranes have been ruptured long enough to allow the liquor amnii to drain away, and if, in addition, the uterus is contracting firmly on the child, it will not be sufficiently mobile to allow of version under the comparatively feeble impulse that can be effected by the action of two fingers. For this is one of the chief difficulties of bi-polar version. Two fingers passed through the os cannot press strongly enough on the accessible part of the fœtus, and if it is not readily mobile it cannot be turned.

A second difficulty is inaccessibility of the child's elbow or knee. These parts of the body may not be reached sufficiently easily by the tips of the fingers to receive a strong enough thrust. But despite these two chief difficulties, the operation is simple and can be quickly performed in properly chosen cases.

The steps of the technique are as follows: A careful abdominal examination is made to determine on which side lies the back, for, if the back is to the right, the operator must use his right hand, and his left hand when the back is to the left. The woman is anæsthetised, set in the lithotomy position, disinfected in the usual way, and catheterised. If the position is such that the back of the fœtus lies to the mother's right, the operator passes his right hand into the vagina and two fingers through the os. If the membranes are intact they are ruptured, and the head is pushed into the right iliac fossa (fig. 2120). Meanwhile the operator presses the fundus of the uterus firmly to push the breech down and to the left. When the head has been dislodged into the iliac fossa, pressure by the left hand on the breech

INTERNAL VERSION

When the os is dilated enough to admit the whole hand, version can be performed by passing it towards the fundus, grasping a foot and bringing it straight down to, and through, the os. It is therefore only possible to employ this method towards the end of the first stage. Under suitable conditions it is a safe, quick, and easy operation, but if the uterus is firmly contracted after a long obstructed labour it is highly dangerous in that it is likely to rupture the lower segment of the uterus.

Indications.—Now that Cæsarean section is so widely used for abnormal conditions, internal version is not employed as much as formerly. Ante-natal treatment has also reduced its application in correcting the shoulder presentation, but there are still cases seen for the first time in which the os is nearly fully dilated, where internal version is ideally useful. The chief example of these is the *shoulder presentation.* If the uterus relaxes between the contractions sufficiently to allow the fœtus to be moved easily, the operation is simple and safe, but if the lower segment has already been unduly stretched by strong contractions which do not relax their grip on the fœtus, the attempt to turn is dangerous because the thin lower segment will almost certainly

being normal, the child is already in a condition of distress. The chance of delivering a live child, already shocked or distressed, by Cæsarean section is small, whereas, though version may add something to the shock, yet the rest *in utero* which follows version with the cord replaced will allow sufficient recovery before the stress of delivery is at hand. If the child is in good condition and the membranes have not ruptured for more than two hours, and if there has been nothing but the minimum and cleanest vaginal examination, then Cæsarean section is, on the whole, the better treatment, but if the child's chances are poor, and if the mother is a case of "suspect sepsis," then, as a rule, bi-polar version is the better method for the indications already mentioned.

METHOD

Certain conditions of labour must be present for the successful performance of bi-polar version. For example, the os must be large enough to admit at least two fingers, and the child must be freely movable. If the membranes have been ruptured long enough to allow the liquor amnii to drain away, and if, in addition, the uterus is contracting firmly on the child, it will not be sufficiently mobile to allow of version under the comparatively feeble impulse that can be effected by the action of two fingers. For this is one of the chief difficulties of bi-polar version. Two fingers passed through the os cannot press strongly enough on the accessible part of the fœtus, and if it is not readily mobile it cannot be turned.

A second difficulty is inaccessibility of the child's elbow or knee. These parts of the body may not be reached sufficiently easily by the tips of the fingers to receive a strong enough thrust. But despite these two chief difficulties, the operation is simple and can be quickly performed in properly chosen cases.

The steps of the technique are as follows: A careful abdominal examination is made to determine on which side lies the back, for, if the back is to the right, the operator must use his right hand, and his left hand when the back is to the left. The woman is anæsthetised, set in the lithotomy position, disinfected in the usual way, and catheterised. If the position is such that the back of the fœtus lies to the mother's right, the operator passes his right hand into the vagina and two fingers through the os. If the membranes are intact they are ruptured, and the head is pushed into the right iliac fossa (fig. 2120). Meanwhile the operator presses the fundus of the uterus firmly to push the breech down and to the left. When the head has been dislodged into the iliac fossa, pressure by the left hand on the breech

brings the elbows within reach of the two fingers, which, in their turn, are also pushed towards the right iliac fossa (fig. 2121). If the child is not freely mobile within the uterus, this movement is difficult and may be impossible, but in successful cases the displacement of the elbow to the right pushes the head out of the iliac fossa into the flank. The fœtus is now transverse, and above the fingers lies the abdomen. Further

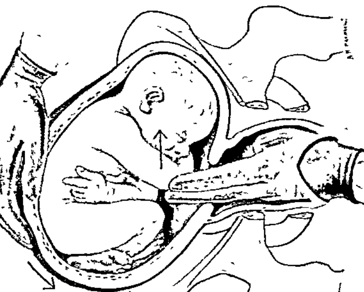


Fig. 2121.—Bi polar version. The head has been pushed to the left side, by which movement the elbow has been brought within reach of the fingers. In the same way the elbow is also pushed away to the left, while the breech is pushed firmly down on the right side towards the brim.

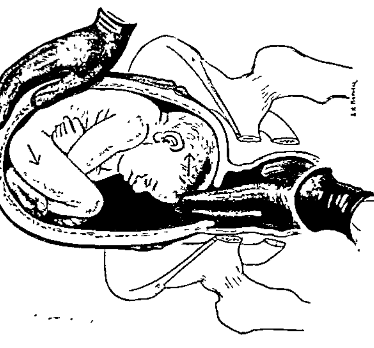


Fig. 2120.—Bi polar version. First stage: Two fingers passed through the os push the head into the iliac fossa, while the right hand pushes the breech out of the fundus. Note that the operator introduces the fingers of the left hand when the child's back lies to the left.

METHOD

The woman is anæsthetised and prepared as already described, and the gloved hand is passed slowly up through the cervix, displacing the head or shoulder to the side on which lies the back. The operator may use either hand according to the side of the child's back.

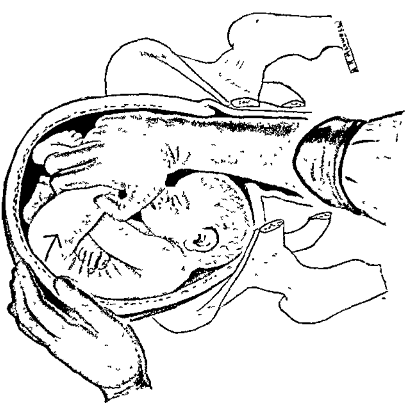


Fig 2124.—INTERNAL VERSION. THE RIGHT HAND IS PASSED UP INTO THE UTERUS TO GRASP THE NEAREST KNEE, WHILE THE LEFT HAND PRESSES THE BREECH TOWARDS THE INTERNAL HAND

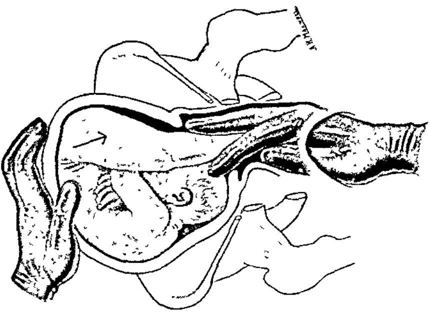


Fig 2125.—INTERNAL VERSION. THE GRIP OF THE FOOT AND PRESSURE ON THE BREECH AT THE FUNDUS

INTERNAL VERSION

When the os is dilated enough to admit the whole hand, version can be performed by passing it towards the fundus, grasping a foot and bringing it straight down to, and through, the os. It is therefore only possible to employ this method towards the end of the first stage. Under suitable conditions it is a safe, quick, and easy operation, but if the uterus is firmly contracted after a long obstructed labour it is highly dangerous, in that it is likely to rupture the lower segment of the uterus.

Indications. Now that Cæsarean section is so widely used for abnormal conditions, internal version is not employed as much as formerly. Ante-natal treatment has also reduced its application by correcting the shoulder presentation, but there are still cases seen for the first time in which the os is nearly fully dilated, where internal version is ideally useful. The chief example of these is the *shoulder presentation.* If the uterus relaxes between the contractions sufficiently to allow the fœtus to be moved easily, the operation is simple and safe, but if the lower segment has already been unduly stretched by strong contractions which do not relax their grip on the fœtus, the attempt to turn is dangerous because the thin lower segment will almost certainly be ruptured.

If the conditions are suitable, internal version may be performed for *brow* and *cord presentations,* if other methods have failed. There are also a few rare cases of *placenta prævia* which have not been previously or adequately treated and in which hæmorrhage is still threatening. If in such patients the os will admit the hand, a rapid internal version can be carried out, the breech can be pulled well down into the pelvic cavity, and then left alone for spontaneous delivery. In former days it was performed in order to deliver rapidly for *eclampsia* and other distressing conditions of the mother. It is recognised now, however, that rapid delivery is the worst possible treatment for eclampsia and for any other condition in which such shock would be dangerous. Internal version to produce a breech presentation has been used by Potter of Buffalo for delivering the great majority of all fœtuses presenting by the vertex. He claims that it abolishes the long delay of the second stage, and so saves the mother pain and fatigue. He also claims that his results compare favourably with normal labour. By long practice Potter himself has become extraordinarily adept at the manœuvre of delivery by version, as the writer can testify by having seen him at work, but it is unlikely that his method will ever be adopted on a large scale.

METHOD

The woman is anæsthetised and prepared as already described, and the gloved hand is passed slowly up through the cervix, displacing the head or shoulder to the side on which lies the back. The operator may use either hand according to the side of the child's back.

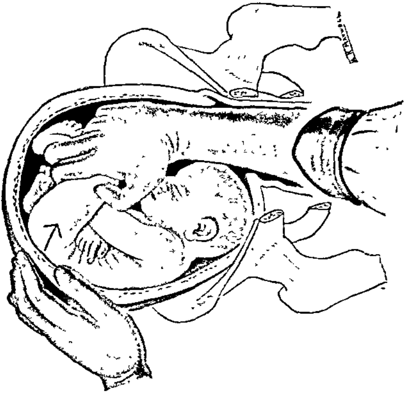


Fig. 2124.—INTERNAL VERSION. THE RIGHT HAND IS PASSED UP INTO THE UTERUS TO GRASP THE NEAREST KNEE, WHILE THE LEFT HAND PRESSES THE BREECH TOWARDS THE INTERNAL HAND

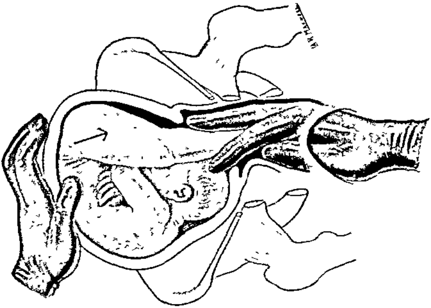


Fig. 2125.—INTERNAL VERSION. THE GRIP OF THE FOOT AND PRESSURE ON THE BREECH AT THE FUNDUS.

If the back is to the left, use the left hand. The passage of the hand into the uterus is liable to stimulate contractions, which render it necessary to keep the hand still until the pain has disappeared. The anæsthetic may have to be deepened if the uterus is irritable. In any case, the hand is manœuvring in a confined space, and, if there is any difficulty, the operator may find that it becomes almost paralysed with fatigue. The object is to grasp a knee (fig. 2124) and then the foot, which is gently pulled down towards the os between the pains. In shoulder presentations it is important to grasp the lower knee or foot

Fig 2126.—The foot has been grasped and pulled down through the os. Meanwhile the external hand pushes up the head from the iliac fossa to the fundus

in order to ensure rotation of the back to the mother's front. Meanwhile the other hand is pressing the breech down (fig. 2125) or trying to move the head up as the internal hand pulls the leg down (fig. 2126). When the leg has been brought through the os, the version is complete, and in nearly all cases it is better to leave the breech within the pelvic cavity for spontaneous delivery. If, however, the fœtus is small or shocked, or the mother exhausted, it is wise to extract the child slowly at once.

Contra-Indications. The outstanding danger of internal version is rupture of the lower segment in cases where the uterus has been for many hours in strong contraction. By the time the state of tonic

contraction has become established the lower segment is stretched and thin and unable to bear any increased tension. No amount of relaxation of the tonically contracted fundus by anæsthesia or other means will alter the attenuated condition of the lower segment. It is a semi-paralytic condition and is incapable of recovery for many hours. Herein lies the failure of adrenalin to relax the uterine condition. While it may inhibit the fundal contraction, though never sufficiently when it has become tonic, the lower segment is incapable of recovering its thickness and normal resistance.

If the uterus is merely "irritable" but not in a state of tonic contraction, the lower segment may not be dangerously thin. Sufficient anæsthesia is capable of abolishing the irritability and rendering the operation safe, but in all cases of labour which has been prolonged there is a risk of the lower segment having become dangerously thin. Internal version should never be attempted for any case in which Bandl's ring—the groove between the thick upper segment and the thin lower segment—can be felt or seen.

CHAPTER III

Forceps

Varieties.

There are four types of forceps in use to-day :

1. The *short straight forceps* is the direct representative of the original instrument invented by Chamberlin in 1600. It has no shank and no pelvic curve, and is therefore smaller and lighter than the long curved forceps. It is seldom used now, but there is no doubt that it is a useful and comparatively safe instrument for extracting the head when it is lying on the perineum.

2. The *long straight forceps* is the instrument most commonly used to-day. It differs from the short variety by the interposition of a shank 2½ inches long between the handle and the blade, and by having a pelvic curve of the blades. It is this curve which adapts the instrument to fit the birth canal and so allows it to be applied to the head as it lies high up in the pelvic cavity.

3. *Axis-traction forceps* (fig. 2127) are similar to the long curved forceps but have in addition an arrangement of traction rods by which the head can be pulled down

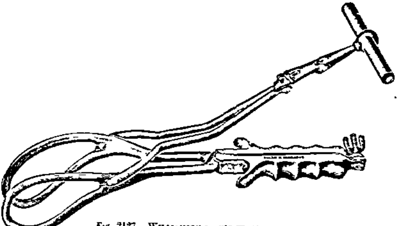


Fig 2127.—Williamson's axis-traction forceps.

in the direction of the birth canal at whatever level the head may be lying. It is designed for use when the head is high or in the brim, in order that traction may be made downwards and backwards. If, when the head is high, the ordinary forceps are used the direction of traction will direct the head not only downwards, but also forwards against the symphysis, whereby much of the mechanical advantage of the traction is lost. Axis-traction forceps are used less now than formerly in view of the tendency to use the forceps only when the head is low in the cavity, but though they have been condemned as dangerous, there are cases where forceps must be applied when the head is at or just through the brim. In such cases, only by the use of traction rods can the head be pulled in the direction of the birth canal, that is, downwards and backwards.

4. *Kielland's forceps is a special instrument differing considerably from the ordinary types.* A description of its details and use will be found on page 3880.

CONSTRUCTION OF THE FORCEPS

The essential features of ordinary long curved forceps are :

(*a*) The instrument should be entirely made of metal, and sufficiently firm to be almost completely rigid without any risk of bending under moderate strain. *There should be a little "give" at the tips of the blades. If the instrument is* too light the blades or shank may bend. On the other hand, it should not be too heavy, as, for example, Tarnier's forceps. This is a valuable instrument for a really difficult extraction, but for ordinary work it is dangerously heavy.

(*b*) The measurements of the various parts of the instrument are more or less standard. The handles should be 5 inches long, the shanks 2½ inches long, the distance between the tips of the blades 1 inch, and the distance between the widest *part of the blades* 3⅜ *inches.*

(*c*) The instrument should be fitted with detachable, axis-traction rods. If the axis-traction mechanism is not required, the forceps can readily be used in the ordinary manner for delivery of the head when lying low in the pelvic cavity. The rods are jointed between their attachment and the traction handle in such a way as to allow free movements of the blades.

There are several different varieties of forceps on the market. In my *opinion Williamson's is the best instrument.* The advantages of these forceps over others are that the traction-rod mechanism is simple and derives its pull from the base of the fenestræ of the blades and not from the handle (as in Neville's and Stack's forceps), also the screw which locks the handles is placed at the end of the handles and so is out of the way of the perineum. In some models this screw is close up to the shank, and when the instrument is applied to a high head the screw may injure the perineum.

INDICATIONS FOR THE USE OF FORCEPS

There have been few topics more debated than the use of forceps, not only the question of the immediate indication, but also, indirectly, the part played by the use of forceps in the production of sepsis and injuries. While it may be an instrument of the utmost value to both mother and child, yet it can, by injudicious use, be made a lethal weapon.

There can be only one general indication for the use of forceps, i.e. insufficient uterine force to expel the child within a reasonable time—by "reasonable" I mean safe for both mother and child. When discussing this subject the books usually describe the list of detailed indications for the use of forceps. I propose to present the subject more from the clinical point of view, describing the clinical types for which the use of forceps is good treatment.

1. *Uterine Inertia.* There are very many labours, often in primigravidæ, in which the contractions and progress have been normal, even rapid during the first stage, and also during the second stage until

the head rests on the perineum and levatores ani muscles. At this stage, when the scalp can be seen between the labia during the pains, further progress seems to stop, at least, a disproportionate amount of time passes before the head descends and stretches the perineum; or, the stand-still may come a little later when the perineum has already begun to distend. In view of the previously rapid progress, the attendant hopes that a little more time with the head at the outlet may be sufficient to allow the woman to deliver herself, but this hope is disappointed by the gradual weakening and failure of the contractions. Particularly is this so if the patient is a primigravida. If no assistance is given, the "pains" pass off entirely, but after a rest of an hour or two they may reappear and ultimately expel the child. But such a method of delivery causes a great deal of unnecessary pain and exhaustion, in addition to a risk of losing the child. Such cases, therefore, are eminently suitable for delivery by forceps at the moment when the weakening pains and failure to advance further make it clear that spontaneous delivery cannot be expected for some long time.

The use of chloroform or other anæsthesia at the end of the second stage is now widely extended to include not only middle-class practice, but also that of many hospitals. A failure of the uterus just at the time when its full strength is required to drive the head through the resistant vaginal orifice is a frequent result of anæsthesia, and therefore forceps are required in the majority of cases

If the instrument is applied cleanly and carefully to a fully rotated head, and extraction is performed gently and slowly, there is a minimum of danger, and great benefit to both mother and child.

2. *Labour with the occiput posterior* If spontaneous rotation of the occiput fails, labour is usually greatly delayed and may be obstructed. Occasionally the head may be delivered quite unexpectedly in the "face-to-pubes" position, but only if the head is flexed, despite the position, or if the child is unusually small. Generally the unrotated head requires the assistance of manual rotation. When this has been done, provided the os is fully dilated, it is the usual custom to apply forceps and deliver.

For multiparæ, and where the os is fully dilated and the head is in the cavity, it is good practice, for in all probability the woman has had a long labour, of which the latter part has been particularly exhausting and painful. A further advantage of immediate application of forceps and subsequent delivery is that, unless it has been possible to rotate the body completely, the head is sure to slip back into the posterior position as soon as the hand's grip has been removed.

There are cases, however, where forceps should not be applied after rotating the head. If both the head and body have been satisfactorily rotated to the front and the os is not sufficiently dilated, no attempt should be made to apply forceps at once.

The common clinical course of these cases is as follows: The membranes rupture before or early in labour, and, from the beginning, the pains are feeble. Many hours, even days, may elapse before the os is half dilated, and an examination made to discover the cause of delay finds an unrotated occipito-posterior position. It is believed that the extended position restrains descent of the head on to the cervix, and thus prevents the natural stimulus for the maintenance of contractions. As drug treatment (morphia, chloral, etc.) has been used without success, it is well to anæsthetise the patient, dilate the cervix sufficiently to insert the hand, and rotate the head and body. The mere change of position of the occiput from posterior to anterior will ensure the flexion of the head. But after rotating the head through the os, which only just admits the hand, it would be dangerous to apply forceps and deliver at once despite the fact that the woman has been in labour some days, unless her condition urgently demand delivery. The rotation of the head, accompanied by the inevitable flexion, is often associated with an improvement in the pains and a fairly quick dilatation. As soon as dilatation is complete, forceps should be applied immediately to save the exhausted mother the final ordeal of unaided expulsion.

The third variety of the posterior position is that for which manual rotation fails—the so-called persistent occipito-posterior. If the child is alive an effort must be made to extract it by forceps after making an effort to flex the head. Sometimes a large pelvis will allow a small head to be dragged through in the uncorrected position, but in many cases no progress can be made. As soon as the child is dead the head should be perforated.

3. *Delay due to contracted pelvis.* The common type is due either to the arrest of the head in the cavity of a pelvis which is generally contracted, or to difficulty caused by the head of a large child in a pelvis which has no pelvic reserve. The clinical features of the labour are those of a uterus tiring after a great effort to drive the head through a small cavity. The woman's general condition will also be that of exhaustion. Vaginal examination will find the signs of pressure. The head will be jammed, with a large caput and strongly overriding sutures, there will be an œdematous anterior lip of the cervix, prolapsed beneath the head, and possibly some œdema of the labia. The child's

heart may be showing signs of distress, or, if the uterus has been contracting very strongly for some hours, the child may be dead. There is no question of Cæsarean section, for in such a case there is no hope of delivering a live child, even though its heart is beating before the operation, and there is also great danger to the mother.

Therefore forceps should be applied and delivery attempted. Axis-traction rods will help, and if the traction is reinforced by a strong thrust of the uterine contractions, there is some chance of delivering a live baby. If during the attempt the fœtal heart ceases to beat, the head should be perforated.

The other variety of contracted pelvis—the flat pelvis—may offer a more difficult problem. Here the head is held up either above or in the brim. Most obstetricians agree that in the former case forceps have no place in the treatment, but if the head is wedged in the brim axis-traction forceps may be used, provided a considerable time has elapsed for full moulding of the head, as proved by the overriding sutures. If there is no superimposed general contraction, the cavity will be normal and the subsequent passage of the head will be easy. Some authorities deprecate the use of forceps in all cases in which the head has not passed the promontory, but if it has descended sufficiently to become well engaged in the brim, the possibility exists that some reinforcement of uterine contractions by artificial help will be just enough to enable the head to pass the brim.

A nice judgment is required to make a decision. If forceps fail, the danger of a subsequent lower segment Cæsarean section is greatly increased, and the child will probably have been severely injured. Chief attention should be paid to the amount of descent through the brim, or how far it is likely that the major diameter is actually in the grip of the promontory and symphysis. If it is still above this strait, forceps offer little hope. Another point is the size of the pelvic cavity and outlet—usually normal in the milder degrees of flat pelvis. If the child is nearly dead the attempt is useless.

In general we may say that it is only exceptionally justifiable to apply forceps when the head is still engaged in the brim, but that there are occasional cases where the operation is worth while.

4. *Delay before full dilatation of the os.* Prolonged delay in the first stage of labour can be a very troublesome and even dangerous complication. The large majority of cases will ultimately complete dilatation with no more treatment than sedative drugs and patience; but of all cases of labour there are about 1 in 60 primigravidæ and 1 in 300 multiparæ who suffer from delay greater than 48 hours, and sufficient

to produce symptoms of exhaustion. After some days of labour the situation may become anxious, and the inevitable question arises—can forceps be used without further waiting? While it is acknowledged to be the worst practice to apply forceps and deliver through the undilated os, yet there are occasionally cases of delay in the first stage which may be more safely delivered by forceps than left for still more hours and days of labour. The signs and indications which may be regarded as justifying the use of forceps before dilatation are as follows:

(*a*) The mother and child should be showing definite signs of exhaustion. Labour may last for days without either suffering from fatigue, but usually after so long a time has passed, especially if the membranes ruptured early in labour, there will be some indications of distress. If both parties are perfectly well, the woman should be allowed to wait and, emphatically, forceps must not be used to save time. But if the general condition of either begins to give anxiety there must naturally be some thought as to how soon delivery can be effected.

(*b*) The os must be *dilatable.* During labour the lapse of time will be associated not only with the dilatation of the os, but also with *softening.* While twelve hours, even if feeble pains have been present, may not be followed by any appreciable increase of dilatation, yet it is probable that the os will be softer and more dilatable than at the beginning of the given twelve hours. It is not uncommon, therefore, to find that, after a woman has been in labour for many hours or days, though the os fails to become fully dilated, yet it is easily dilatable by the hand under anæsthesia.

If it is found that the os can be easily dilated by the hand—and it is often surprising to find how easily this can be done after hours of contractions have failed—and other conditions are favourable, forceps may be applied. Before any traction is made, the head is held in position while the fingers of the left hand complete the dilatation by pushing the rim of the os up over the head. Push it up first behind, then at the sides, and finally at the anterior lip. When the edge of the os can no longer be felt, the head can be pulled and extracted in the usual way.

If forceps are applied before full dilatation, it is always most important to push the whole of the cervix above the head rather than attempt to pull the head through it. If this is done, even gently and slowly, serious tears are inevitable, but if the os is pushed up, it may be possible to deliver without any but the smallest laceration.

(c) Any maternal condition which renders further delay during the second stage a source of exhaustion or danger. The best example is

strong probability of successful passage of the head, but it is usually the doubtful cases which cause most anxiety. The chief points for consideration are as follows:

(a) Continued and steady progress, even if slow, usually indicates that an additional force applied through the forceps will so assist the force of the uterus that successful delivery will be accomplished.

(b) An anterior occiput, completely flexed, affords a hope of delivery, but it is quite certain that the opposite conditions of posterior occiput and absence of flexion will effectually prevent it in a borderland case of pelvic contraction.

(c) If, during a pain, the head can be felt to descend, or if, between the contractions, the head can be pushed up by the finger, an attempt to deliver by forceps may be made, as these movements indicate that so far there is not complete impaction. But if the head cannot be made to move, and if, in addition, the maximum moulding has already occurred, as shown by great overriding of the bones (should it be possible to feel the sutures), there is little or no hope of extraction.

Great œdema of the scalp (caput succedaneum), of the cervix, and even of the vulva, nearly always indicates impaction. The presence of much œdema means that for some hours, at least, the uterus has been contracting strongly, and if, in spite of this, progress has come to a standstill, there is little chance of success with forceps, but if the caput is small and there is no œdema of the cervix, then the contractions have never been strong, and failure to progress may be less the result of mechanical disproportion than of failure of expulsive force. Forceps in this case may succeed.

5. Forceps should never be applied in the presence of *tonic contraction* of the uterus, because this condition invariably indicates insuperable obstruction and an already dead child.

6. In all the books and teaching, emphasis is laid upon the danger of extracting the fœtus in the *absence of pains*. This injunction refers to the state of true uterine exhaustion, or so-called secondary uterine inertia. It is a state which follows prolonged and hard contraction, due to some obstruction either relative or absolute. The danger lies in the complete inability of the uterus to contract after delivery. Atonic and probably fatal post-partum hæmorrhage is then inevitable. A much commoner clinical condition of absence of pains is primary inertia which may first occur when the head has come down to the perineum. In this case there is no actual exhaustion nor total incapacity of the uterine muscle to contract, but only a reflex inhibition, due to no certainly known cause. The introduction of forceps and extraction

removes the inhibition, and is followed by contractions sufficient to prevent post-partum hæmorrhage. Indeed, it is a rare event for hæmorrhage to follow the labour of primary inertia.

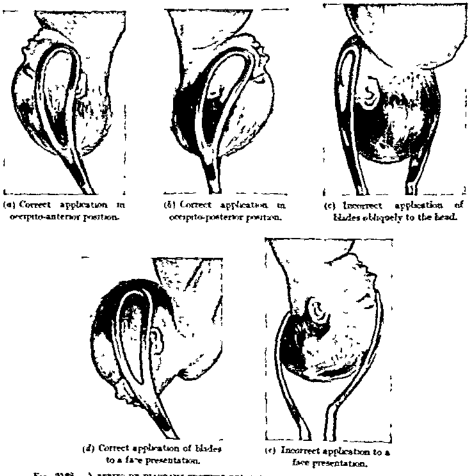
When the head has descended far enough for the application of forceps, there may be considerable doubt whether it is safe to deliver when the uterus is apparently not contracting. There is a natural fear of delivery in the absence of pains, and yet the tired state of the mother or child may be a strong indication to terminate labour. In the state of primary inertia the uterus is always potentially able to contract, and will do as the child is delivered; but in uterine exhaustion the muscle is clinically paralysed and cannot contract. Signs of pressure, such as a large caput, œdema of the anterior lip of the cervix, and extreme moulding, will be present. Some cause of obstruction, for example, occipito-posterior or contracted pelvis, will probably be obvious. Further, the child will be distressed or even dead, and a hand held on the uterus for some minutes will feel it entirely and continuously soft, without the slightest trace of hardening. In primary inertia there are no signs of strong pressure, the uterus has been sluggish during the whole labour, the child is well, and though there are apparently no pains, yet the hand will feel slight rhythmical hardening which indicates that the uterus is potentially able to contract. In the latter case, forceps may be applied with perfect safety.

METHODS OF APPLYING FORCEPS

The patient must be anæsthetised and placed either on her back or left side. The vulva is shaved, unless this has been done already, and cleansed with a suitable antiseptic lotion such as dettol. A catheter is passed before any internal examination is made. It is most important that the bladder should be emptied before delivery.

After all the preliminaries are completed the left hand is passed slowly and gently into the vagina. In a primigravida there may be difficulty in inserting the hand without tearing the perineum. Should the introitus be tight, special care must be taken to pass the knuckles slowly in order to dilate rather than tear the perineum. This, and gentleness expended in passing the hand, will, by stretching the resistant tissues, do much to facilitate delivery and prevent a deep tear as the head emerges. When the hand has at last been introduced it is well to spend a minute or two in "ironing out" the posterior vaginal wall with the back of the hand. This should be done slowly and carefully by pulling the left hand down on the posterior vaginal wall and perineum so as to secure as much stretching as possible. Before the blade of the

forceps is passed the left hand must find out certain details. Firstly, whether the os is fully dilated and has slipped up above the head. It is also essential to confirm the exact position of the head. Even though a first or second vertex position has been known to exist at the beginning of labour, it is wise to examine at this juncture, just before the application of the forceps blades, to be quite sure that the head is not lying



(a) Correct application in occipito-anterior position.

(b) Correct application in occipito-posterior position.

(c) Incorrect application of blades obliquely to the head.

(d) Correct application of blades to a face presentation.

(e) Incorrect application to a face presentation.

Fig. 2128.—A series of diagrams showing relations of the blades to the child's head, in the various presentations of anterior, posterior vertex, and face.
(*From Eden and Holland's "Manual of Midwifery"*)

in the occipito-posterior position. Again, either the sagittal axis of the head may be lying unrotated in the oblique diameter of the pelvis, or internal rotation may have been completed before the head reaches the perineum. Should the blades be applied strictly in relation to the lateral walls of the pelvis when the head has not yet rotated, the grip will be partly over the face, and may cause serious bruising or even damage to the orbit. Not only may the head or face be injured, but an oblique grip of the head is liable to allow the forceps to slip under even

gentle traction (fig. 2128). A further disadvantage of the oblique grip is that the head will almost certainly be extended by traction. This movement will throw a larger diameter across the pelvis and will thus add to the difficulty of extraction. It is most important, therefore, to grasp the head accurately in the transverse diameter. There is less chance of injury, slipping of the blades, or extension of the head. If the head is found in the oblique diameter, the blades must be applied asymmetrically in relation to the pelvis, so as to grip the head squarely. As the occiput rotates from the oblique to the antero-posterior diameter, the forceps will also pass round the eighth of a circle, and so come to lie in the transverse diameter of the cavity, and later, in the outlet. Despite the pelvic curve of the instrument, no harm will be done to the soft tissues by rotation of the blades through this small arc.

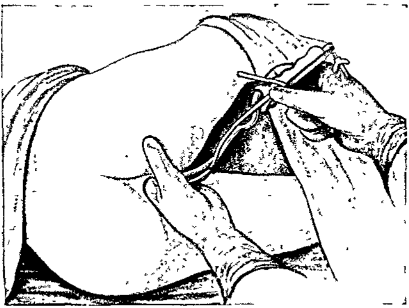


Fig 2129.—THE APPLICATION OF THE LOWER OR LEFT BLADE
(*From "Queen Charlotte's Text Book of Obstetrics"*)

Introduction of the left (or lower) blade. We will assume that the patient is lying on her left side. The operator's left hand has been carefully introduced so as not to tear the perineum, it has spent a few minutes in gently stretching (or "ironing out") the posterior vaginal wall and perineum, and it has ascertained that the cervix has slipped above the head, and the exact position of the head in reference to the pelvis. The hand is laid flat against the side of the head, between it and the cervix. The right hand now takes the handle of the left or lower blade and passes the blade into the vagina with the tip closely applied to the palm of the internal hand (fig. 2129). The handle is at first elevated,

but as the blade passes up the vagina it is gradually lowered until the whole blade is horizontal. The blade slides in until it has found its position, snugly applied to the side of the head. As I have already explained, it will probably not lie in the transverse diameter of the pelvis because the head still occupies its oblique diameter. The internal hand is then passed round the pelvis to find the other lateral surface of the head, while at the same time the left elbow is used to steady the position of the blade just inserted. In the same way the right (or upper) blade is passed, by holding the handle depressed, and gradually lifting it as the blade slides into position against the side of the head. If the blades make a "square" grip of the head, the handles will almost drop together

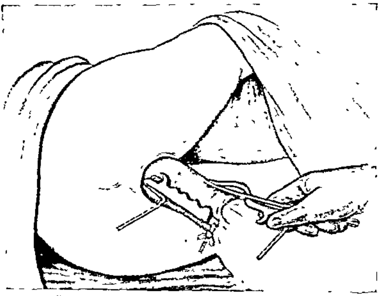


Fig. 2130—The application of the upper or right blade.
(*From "Queen Charlotte's Text Book of Obstetrics."*)

and can easily be locked without any force (fig. 2130). Ready locking of the blades is a sure sign that the head is grasped by its transverse diameter.

Before any traction is made, the left hand makes a final examination to be sure that no maternal tissues, or the cord, are gripped by the instrument.

Traction. A preliminary pull should be made while the left hand is in the vagina in order to note that there is no tendency for the blades to slip. The hand is then removed, and the handles held in the right hand with two fingers over the shoulders at the junction of the handle and shanks (fig. 2131).

There are several details in the process of traction which must be described, because it is due to faults at this stage of the operation that

injuries can occur. The first essential is to pull only *with* the pains. There may be no obvious contractions since the woman is anæsthetised, but often the act of pulling stimulates a contraction, or if the uterus appears to be completely flaccid, a few minutes of delay will usually allow a small but definite hardening of the uterine wall to be felt. The importance of pulling during the contractions is that the thrust of the uterus, even during a feeble pain, adds considerably to the force exerted by the forceps. It is often noticed that while no appreciable descent can be made by pulling while the uterus is flaccid, yet as soon as it hardens traction on the head at once becomes effective.

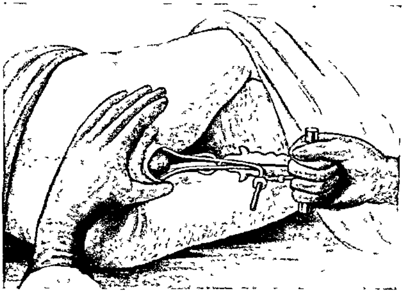


Fig. 2131 —Traction on the forceps is being directed forward as the head is distending the perineum

(*From* "*Queen Charlotte's Text Book of Obstetrics.*")

The amount of force exerted by the operator is important. In the ordinary case of "low forceps", no more force is necessary than can be exerted by the wrists and elbows, but in cases of disproportion or incomplete flexion it is usually necessary to pull firmly from the shoulder. Stronger traction than this is often employed, but is dangerous, both to the child's head and the birth canal. As the head is beginning to distend the perineum, *episiotomy* will always reduce the amount of traction required in a primigravida, and will also often save a rupture of the perineal tissues.

The time required for forceps delivery varies according to the circumstances of the case. Where the head is just lying above the perineum, it may be lifted out within two or three minutes, but if it is partially impacted high up in the cavity, traction may have to be exerted for half an hour or more. So long as the operator feels that each pull

produces some degree of descent, even though quite small, there is justification for continuing, but if with the strongest permissible force there is no sensation of descent after 15 or 20 minutes, further efforts are usually hopeless. The child will probably be dead, and, if so, a perforator should be passed into the head between the shanks of the forceps. The reduction of the size of the head allowed by the escape of brain substance will nearly always enable the extraction to be finished without great difficulty.

Occipito-posterior presentations. The ideal treatment is to rotate the head and deliver by forceps, but occasionally it is impossible to rotate the head by hand. and the question arises of attempting to rotate it by the forceps. Many obstetricians think this is a dangerous practice because, where manual rotation has failed. the force necessary to be exerted through the forceps is so great as to be dangerous. A better practice is to attempt to pull the head down with a gentle rotary movement applied during the traction. In this way, the rotation that usually accompanies descent is encouraged by the extra assistance given by the forceps, and gradually the head may be brought round. As the head rotates and the blades thus come to lie asymmetrically in relation to the pelvis they should be removed and reapplied.

Face presentation. A common trouble in face labour is delay due to inertia. Where the conditions are suitable, forceps extraction is good treatment and offers no special difficulty. As the comparatively long submento-vertical diameter must pass under the perineum, an episiotomy is particularly useful to avoid perineal tears.

The after-coming head. Some obstetricians are accustomed to deliver the after-coming head by forceps, but most of us extract it by one of the familiar manœuvres. If there is impaction sufficient to prevent delivery by the jaw-traction method, forceps may be successful, but by the time forceps are applied, too much time has already been absorbed in attempts to deliver by hand. During the application of the blades the child's body must be pulled well forward towards the symphysis.

KIELLAND'S FORCEPS

The following description of these forceps was given to me by Dr. Kielland on the occasion of his recent visit to Queen Charlotte's Hospital.

The instrument was first introduced by him in 1915, but even now it has not been widely used in England. It is more difficult to apply, but nevertheless there are definite indications for its use in selected cases.

Kielland's forceps differ from all other types of modern forceps in the following respects (fig. 2132):

1. The pelvic curve is considerably reduced. The blade therefore resembles that of the old straight forceps, except that it is inclined a little posteriorly on the shank.
2. There is no alteration in the radius of the cephalic curve. The tips of the blades are separated by 2·2 cms., and the maximum separation is 8 cms.
3. Apart from the absence of pelvic curve, the most striking difference from orthodox forceps is in the lock. There is no actual lock, but a slot on one shank, *by which the shanks and handles merely slide one along the other* in a longitudinal direction. This arrangement thus allows each blade to grip the head at a different vertical level.
4. The shanks are considerably longer than those of ordinary forceps, and they are straight from the handle to the blade. The part immediately below the fenestrated portion is light, thin and rounded. The whole instrument is lighter and more slender than any other form of forceps.

The object of the forceps is to grasp the head symmetrically, no matter how it lies in the pelvis. The long diameter of the head usually lies *in the transverse diameter of the brim and cavity before the os is*

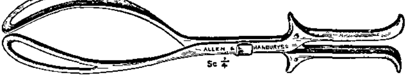


Fig. 2132.—Kielland's forceps

fully dilated, and frequently after the rupture of the membranes it still lies in this diameter, or, in the case of the occipito-posterior positions, it will lie in the oblique diameter. It is often only towards the end of the second stage that the sagittal diameter rotates from the transverse through the oblique to the antero-posterior diameter. It therefore follows that the grip of the head by the ordinary forceps, applied conventionally with regard to symmetry with the pelvis, will often grip the head askew. One blade may even grasp the forehead and the other the occiput, but Kielland maintains that his forceps can grasp the head however it lies in the pelvis, so that both blades are laterally placed on the skull. Further, as the head rotates with downward traction, the forceps can follow this movement because they have no pelvic curve. He also states that the application of the ordinary forceps in unrotated cases is liable to push the head into the occipito-posterior position or to extend it. It is not the high position of the head which renders the operation dangerous and difficult, but the wrong application of the blades in relation to the transverse diameter of the fœtal head. By eliminating this difficulty he claims that his instrument may be used without danger for "high forceps" extractions.

The following points should be observed in applying Kielland's forceps:

1. With the patient anæsthetised and lying on her back in the lithotomy position, a careful examination is made by the whole hand to find exactly how the sagittal diameter is placed in reference to the pelvis. It is most important that there should be no doubt on this point.

2. Take the forceps, articulate the blades and hold them at the vulva exactly as they must be applied to the head in the position which has just been ascertained. The concavity of the slight pelvic curve

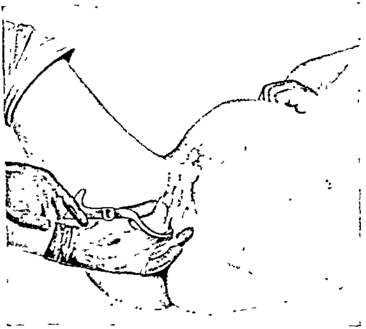


Fig. 2133.—Introduction of the anterior blade, which is passed in front of the head. (See also *Fig.* 2134.)
(*From Bourne and Williams' "Recent Advances in Obstetrics and Gynæcology"*)

should be directed towards the occiput, so that when the occiput has rotated to the front the forceps will correspond to the curve of the sacrum.

3. Next, take hold of the anterior blade by the fenestrated portion (not the handle) and lay the other blade aside. Then transfer the grasp to the handle.

4. Introduce the hand into the vagina and pass two fingers between the fœtal head and the symphysis. Pass the anterior blade, guided by the left hand, into the vagina with its *concavity towards the symphysis*, until its tip touches the head (fig. 2133). Then lower the handle slightly and pass the blade between the cervix and head until the middle of its concavity is behind the symphysis.

5. Rotate the handle slowly through 180° on its long axis, towards the side on which the button is situated on the handle. The blade will now lie snugly over the side of the fœtal skull (figs. 2134 and 2135).

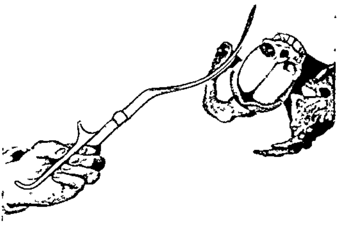


Fig 2134.—DIAGRAMMATIC REPRESENTATION OF THE MANŒUVRE SHOWN IN *Fig.* 2133.
(*From Bourne and Williams' "Recent Advances in Obstetrics and Gynæcology"*)

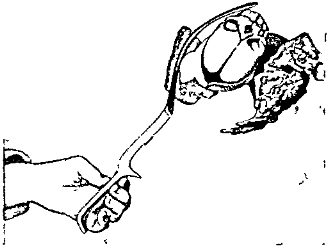


Fig 2135.—SHOWS THE POSITION OF THE BLADE AFTER IT HAS BEEN ROTATED FROM THE POSITION SHOWN IN *Fig.* 2134.
(*From Bourne and Williams' "Recent Advances in Obstetrics and Gynæcology"*)

6. The posterior blade is introduced as follows: "Pass two fingers into the vagina between the posterior cervical lip and head; pass the second blade posteriorly *on the side where the lock will approximate to that of the first blade,* and introduce it gently to the side or in front of the promontory. The blade meets no resistance unless the pelvis is contracted or the head impacted low down. In that event do not use force, but gently manipulate it by lowering or lifting its handle." (Bourne and Williams.)

7. After articulating the blades, pull gently. The blades will slide a little on one another, so that one will lie at a slightly higher level than the other. This is due to either blade adjusting itself to the different

levels of the sides of the head relative to the pelvis. The forceps lie in the antero-posterior diameter of the pelvis, and have gripped the head symmetrically in its transverse bi-parietal diameter.

8. Draw the head downwards and backwards, allowing the forceps to follow the rotation of the head. As it descends still lower, assist the rotation already indicated by an active movement of the handles. Towards the outlet the occiput will come to lie to the front, but during extraction take care not to pull too much in a forward direction, as with ordinary forceps.

9. In the unrotated occipito-posterior position the blades are inserted as before, except that in order to grasp the head squarely they will lie first asymmetrically in relation to the antero-posterior diameter of the pelvis. After application, rotate the head before applying traction, and then draw it down.

Kielland's forceps should not be used:

1. In a contracted pelvis where the head remains above the brim.

2. When the lower uterine segment is stretched and a retraction ring is present.

It is important to have practised the use of the instrument on a manikin, and to be sure of the diagnosis of the lie of the fœtal head.

The advantages of Kielland's forceps are:

1. The grasping of the head by its bi-parietal diameter, as a consequence of which the forceps cannot slip off the head.

2. Because the blades fit the head closely, this instrument is safe for rotation.

3. The blades are applied to that part of the child's head which can best endure pressure, namely the cheeks and the underlying bones. There is no pressure on the orbit, brow, nose, neck, or facial nerve as so often occurs when the ordinary forceps are applied to an unrotated head.

4. The head is not displaced by the introduction of the blades; this can be of importance when the pelvis is somewhat contracted.

5. As less traction is necessary for delivery than with ordinary forceps there is less risk of maternal injuries. (Bourne and Williams' *Recent Advances in Obstetrics and Gynæcology*.)

CHAPTER IV

Destructive Operations

CRANIOTOMY

The operation of craniotomy is performed to reduce the size of the fœtal head in certain cases of difficult delivery. It consists of two or three procedures: 1. Perforation; 2. Extraction; 3. Cranioclasm.

1. *Perforation.*

It is necessary to perforate the skull in order to allow the escape of brain substance, after which the cranial bones are able to collapse. For this purpose an instrument called a perforator is used. Of the various patterns on the market the best is Oldham's (fig. 2136). It

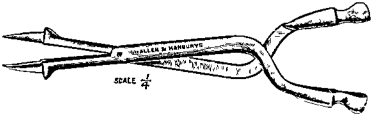


Fig. 2136.—Oldham's perforator.

consists of two blades articulating by a screw lock. Each blade has a handle, a long shank, and a sharp-pointed member an inch long, with a moderately sharp outer cutting edge. The shank carries a shoulder at the base of the perforating member, which is important in so far as it prevents the whole length of the instrument being pushed suddenly into the skull.

Indications. For all cases of difficult delivery due to contracted pelvis or disproportion between the size of head and pelvis, or impaction of the head in the posterior face, or brow positions, when the child is dead or actually moribund, and after reasonable efforts to deliver by forceps have failed, perforation may be performed. If the child is dead it is not necessary that labour should be completely obstructed —perforation should be carried out if unnecessarily hard traction by forceps is required, even if some progress is being made. Less trauma is likely to arise from perforation followed by extraction than from continuation of fruitless attempts at rotation of an impacted occipito-posterior, or strong efforts to deliver an impacted after-coming head.

It is necessary that the os should be fully dilated before extraction is attempted, but perforation alone may be done when the os is not more than half dilated. In some cases of very resistant dilatation it may be useful to perforate the head and fix a cranioclast thereto. A weight attached to the cranioclast will then produce a constant tractive force which will often overcome rigidity of the os. In general, however, the os is fully dilated by the time the fœtus is dead. It is rare that the os is too small for the use of the perforator.

Extreme degrees of contracted pelvis are unusual in this country, but in some parts of the world they are not so uncommon. Before attempting delivery by craniotomy it is necessary to be sure that the pelvis is not so greatly contracted as to render extraction impossible. The writer's experience contains one such instance. After prolonged efforts to break up the head and draw it through the brim (true conjugate of $2\frac{1}{2}$ inches or less), it was found impossible to extract the body, and Cæsarean section was performed. The patient survived, but the abdominal wound sloughed. The question of perforation of a live child is often discussed, but it seldom arises in practice. By the time that efforts to deliver by forceps have been given a fair trial in cases of obstruction, the child is usually moribund or dead. It is dead in all cases of obstructed labour that have reached the stage of tonic contraction, and in nearly all cases of "failed forceps" the shock to the child is such that, though not actually dead, the chance of survival after Cæsarean section delivery is very slender.

In cases where the child is in good condition but impossible to deliver alive by the vagina, the lower segment Cæsarean section offers a comparatively safe method, even after the membranes have been ruptured some hours and vaginal examinations have been made. Finally, obstructing hydrocephalus should always be perforated.

Operation. The patient is anæsthetised and placed on her back in the lithotomy position. Most careful disinfection of the vulva and vagina is made by dettol or iodine in glycerine. This is necessary because of the probable presence of infection following a long period of labour and previous manipulations.

The left hand is passed into the vagina until the head can be explored. The perforator is taken in the right hand and passed along the left hand so as to protect the maternal parts from damage by the blades. The points of the blades are pressed firmly against the head at right angles to the surface in order to avoid slipping, and if possible over bone and not over a suture (fig. 2137). In the case of a face presentation the instrument should be passed into the orbit.

Slight pressure is used at first to pierce the scalp. After the points have perforated the scalp there is little danger of their slipping off the head, and then firmer pressure is made to pierce the bone. This follows in a few moments and allows the blades to sink into the skull up to the shoulder of the shank. The handles are closed, by which action the blades are opened and the bone broken ; they are then opened, rotated through a right angle, and closed again (fig. 2138). This double opening and

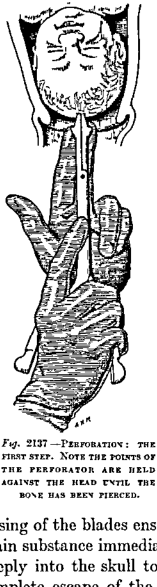


Fig. 2137.—PERFORATION: THE FIRST STEP. NOTE THE POINTS OF THE PERFORATOR ARE HELD AGAINST THE HEAD UNTIL THE BONE HAS BEEN PIERCED.

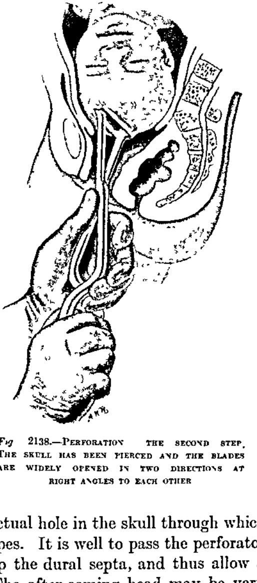


Fig 2138.—PERFORATION THE SECOND STEP. THE SKULL HAS BEEN PIERCED AND THE BLADES ARE WIDELY OPENED IN TWO DIRECTIONS AT RIGHT ANGLES TO EACH OTHER

closing of the blades ensures an actual hole in the skull through which brain substance immediately escapes. It is well to pass the perforator deeply into the skull to break up the dural septa, and thus allow a complete escape of the brain. The after-coming head may be very difficult to reach if it is held up at the brim. Strong traction by an assistant is made on the legs downwards and backwards, in order to bring the occiput as low down as possible behind the symphysis. It is palpated by the fingers of the left hand, and the blades of the perforator are passed, very carefully guarded by the left hand, to reach the

occiput just above the nape of the neck. Pressure must be made with great care as the blades are probably not at right angles to the bone, and are therefore liable to slip if firm pressure is made before the scalp is pierced.

In all cases of minor disproportion or impacted occipito-posterior, the head can usually be delivered easily by forceps after the rigidity of the head has been destroyed by escape of the brain. It is most convenient, therefore, to apply the forceps first, and then to pass the perforator into the skull between the shanks of the forceps. As soon as the dural septa have been broken up, the head will usually descend easily when traction is made by the forceps. The contrast between the firm and " hopeless " resistance offered by the head before perforation, and the ease with which it can be drawn down after perforation, is very striking.

2. *Extraction.*

As I have just described, the fœtus can in the majority of cases be delivered by forceps after perforation alone. If the pelvis is severely contracted it will be necessary either to crush the head or actually to break it up by the cranioclast.

There are two main varieties of the cranioclast, the one (Braxton-Hicks' or White's modification) which is composed of two blades, and

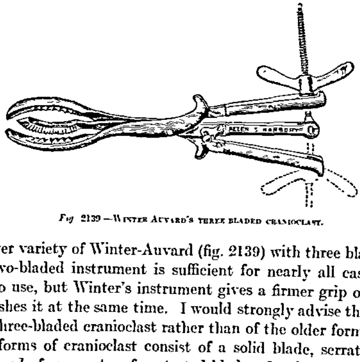


Fig 2139.—Winter Auvard's three bladed cranioclast.

the newer variety of Winter-Auvard (fig. 2139) with three blades. The older two-bladed instrument is sufficient for nearly all cases, and is easier to use, but Winter's instrument gives a firmer grip of the head and crushes it at the same time. I would strongly advise the purchase of the three-bladed cranioclast rather than of the older form.

All forms of cranioclast consist of a solid blade, serrated on one aspect, and of one or two fenestrated blades, deeply serrated on their

concave surfaces. Both the fenestrated blades articulate with the central blade, as shown in the figure. The ends of the handles are provided with a separate member which enables the three blades to be screwed tightly together. It is important that the cranioclast be heavily and strongly made, in order to ensure a very firm, unyielding grip of the head. One of the chief difficulties in the practical use of the instrument is its tendency to slip off the head owing to the imperfect grip and the very strong traction that may be necessary.

The cranioclast as a tractor. For moderate degrees of contracted pelvis it is usually possible to deliver without actual cranioclasm, but by traction alone. A sufficient grip of the head can be obtained by using only the solid and No. 2 blades of Winter's instrument. Having perforated the skull and stirred up the brain, the solid blade is passed through the hole deep into the skull with its serrated convexity directed towards the face. It is not always easy to keep it exactly in position because of the weight of the shank and handle, and therefore an assistant should be present if available. It is important to pass this blade well into the skull, as deeply as possible. The blade No. 2 is then passed over the face, with its concavity directed towards the face. Care must be taken in passing this blade to protect the maternal tissues from injury, by the left hand, and also to pass it far enough up to bring its lock into apposition with that of the solid blade. A firm grip and freedom from slipping are ensured chiefly by passing both blades far enough to grasp the whole face in their concavity (fig. 2140).

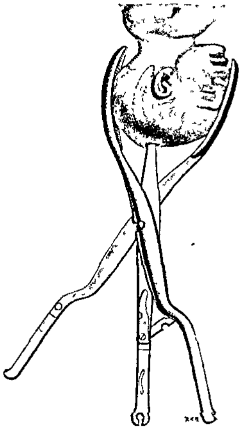


Fig. 2140.—CRANIOTOMY. THE CRANIOCLAST IS APPLIED FOR USE AS AN EXTRACTOR. NOTE THAT ONE BLADE IS PLACED SO AS TO GRASP THE FACE

When the operator is satisfied that the blades are in good position, the handles are screwed together as tightly as possible, and pulled downwards and backwards. After the fruitless struggle to deliver with forceps, the quick and easy descent which follows traction on the cranioclast is surprising and gratifying.

During the first few moments of pulling much more brain tissue escapes, showing the collapse of the skull caused by descent through the pelvic cavity. If there is initial difficulty, or failure to bring the head down, try to rotate the face round to the front or back. This movement produces still more collapse of the head and renders descent possible. It is always advisable to twist the head a little in rotatory movement, to and fro, to ease the grip of the pelvis and force a further collapse of the head.

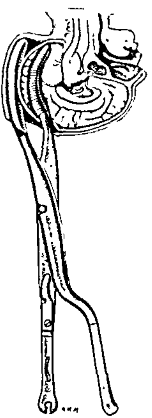


Fig 2141 —Cranioclasm The use of the cranioclast to break up the bones of the cranial vault The external blade is passed beneath the scalp in order to grasp the bone only

Occasionally it may still be very difficult to draw the head down even when the left hand can feel that it is lying quite loosely in the pelvis. This always means that the shoulders are held up, either by the contracted brim or by a contraction ring. This is a serious additional complication, to which we shall refer again later.

Should the pelvis be too small for extraction as we have just described, or if the two-bladed instrument slips, apply blade No. 1 with its concavity over the occiput and exactly opposite to blade No. 2. When this handle is screwed home the head is crushed and flattened in the opposite diameter. This elongated diameter is now rotated until it is brought into the transverse diameter of the brim, where there is most room in cases of flat pelvis.

3. *Cranioclasm.*

In extreme degrees of contracted pelvis it may be necessary to break up and remove the calvarium piecemeal. This is a laborious and dangerous operation because of the risk of infection caused by repeated introduction of hands and instruments into the vagina. It is also difficult because in nearly every case the head is entirely above the brim, and unless the greatest care be taken it is easy to injure the maternal tissues. The operation is performed as follows: After perforating the skull, the solid blade of the cranioclast is inserted deeply into the hole with its convexity against the parietal bone. The tip of the fenestrated blade is then insinuated between the bone and the scalp at the edge of the hole made by the perforator. Having once found the line of cleavage between the two, it is easy to push the blade over the bone and

under the scalp as far as the origin of the parietal bone from the base of the skull (fig. 2141). The second blade is passed in this manner to lie opposed to the solid blade which has been previously passed, and when both are pushed home, the instrument is locked as tightly as possible. The blades have a firm grip of the parietal bone, and by a twisting action a piece of the bone is wrenched away. This is carefully drawn out, shielded by the left hand so as to protect the vagina from being scratched and torn by the sharp edges of the bone. This process is repeated until the whole of the vault of the skull is removed, and only the face and base of the skull remain. An attempt is next made to extend the head in order to produce a face presentation. This may be extremely difficult, but if it can be done the subsequent extraction will be much easier. The solid blade is forced into the mouth as far as possible and the fenestrated blade passed over the supra-orbital region, so that when the handles are screwed together the face is crushed and gripped. Having gained a firm hold, traction is made on the instrument to pull the crushed head through the brim.

EMBRYOTOMY

In some cases of obstruction it is necessary to break up the body of the fœtus. All these manœuvres are included under the term embryotomy.

Decapitation. When the child presents by the shoulder it is possible to convert it to a breech presentation during the earlier stages of labour. After the uterus has become tonic or even "irritable," with short and imperfect relaxation, version is dangerous on account of the risk of rupture of the lower segment. At this advanced stage of labour the

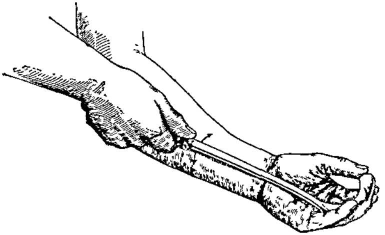


Fig. 2142.—Shows the method of introducing the decapitation hook, whereby the left hand prevents it from injuring the vagina.
(*From Eden and Holland's "Manual of Midwifery."*)

child is invariably dead, and can only be safely delivered by decapitation. Division of the neck breaks the obstructing wedge, and allows first the body to be delivered, and then the head. For all shoulder presentations when the child is dead it is advisable always to decapitate rather than to perform version if there is any risk of the lower segment having become dangerously thin by the previous action of strong fundal contractions. The prolapsed cord will readily give information as to the condition of the fœtus, and an inspection and careful palpation of the abdomen will determine, firstly, if the uterus is contracting very strongly, and, secondly, if there is a palpable ridge and groove between the upper and lower segments, commonly called the retraction ring of Bandl. Unless the uterus relaxes freely between contractions, or in the presence of Bandl's ring, version is too dangerous and must not be attempted. Even if the contractions are considerably reduced by anæsthesia, the lower segment still remains very thin and must suffer great strain during the process of version.

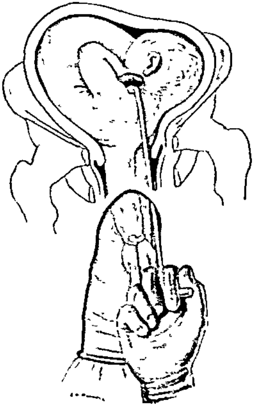


Fig. 2143.—Decapitation. Note the finger of the left hand which has guided the tip of the hook over the neck.

Operation. The patient is anæsthetised, placed in the lithotomy position, and most carefully disinfected with tincture of iodine or any other suitable disinfectant. An assistant pulls on the prolapsed hand in order to bring the neck well down over the brim of the pelvis. The left hand explores the conditions inside, and then shields the shard decapitation hook as it is passed up in front of the prolapsed arm (see fig. 2142). The shaft of the hook is passed so that it lies towards the head, and the point in the direction of the breech. Great care must be taken, as the hook reaches the level of the shoulder, not to damage the tissues behind the symphysis. The hook must be " eased " by the left hand rather than forcibly pushed by the right hand (fig. 2143).

As soon as the hook is high enough to allow the tip to clear the child's shoulder, it is turned to bring it at right angles over the neck. The left hand is then partially withdrawn and passed up on the posterior aspect of the neck in order to feel for the point of the hook. When the tip is safely covered by the fingers the hook is gently but firmly pulled down over the neck. At this stage there is danger of wounding the rectum or other soft tissues by the tip of the hook unless the fingers of the left hand are careful to act as a shield.

Before the act of cutting through the neck, the left hand ascertains that the hook fits snugly over the narrowest part of the neck, and is not

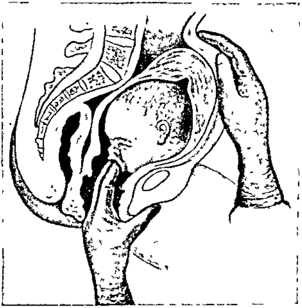


Fig 2144.—Extraction of the head after decapitation by a finger in the mouth assisted by strong fundal pressure. This is only successful if the head is small.
(From "Queen Charlotte's Text Book of Obstetrics")

lying obliquely over the neck and one shoulder. The actual decapitation is carried out by a pendulum action of the hook in the sagittal plane. The handle is carried forwards (or upwards) towards the symphysis, and then pulled strongly downwards and backwards. At the end of the down stroke it is brought back to the upper position without traction, and then again it is pulled strongly down and back. During all these movements the fingers of the left hand are held carefully on the tip to ensure that it does not injure the maternal tissues.

The hook does not cut through the upper skin of the neck easily, but after this is divided, it quickly passes through the soft tissues and even through the spine. The lower skin is apt to be pulled down by the hook before it is cut, and care must be taken at this stage that not too much traction is made with the down stroke, or the skin will be suddenly divided and the hook will thereupon be pulled hard downwards, with

the risk of striking the rectum or sacrum through the posterior vaginal wall.

When the neck has been divided, pulling on the prolapsed arm will deliver the child's body. The head remains above the brim—often a difficult problem. If the pelvis is normal it is usually a simple matter to insert the fingers into the mouth, produce a face presentation, and then draw it down assisted by strong fundal pressure (fig. 2144). The hole in the spinal canal will allow some of the cerebral matter to escape, but where the pelvis is definitely contracted it may be necessary to crush the head in the usual way, after perforating the cranium.

If the uterus is in tonic contraction, decapitation is an anxious and dangerous operation, because even the introduction of the hand and hook may rupture the extremely thin lower segment. No amount of anæsthesia or other drugs (such as amyl nitrite) can render the lower segment less thin and fragile, even though the tone of the fundus may be relaxed.

CLEIDOTOMY

Difficulty in delivery of the shoulders is common where the child is unusually large, in some cases of anencephaly, in contracted pelvis, and in the rare condition of contraction ring (hour-glass contraction of the uterus). The operation of cleidotomy consists in cutting through the clavicles with a strong pair of blunt-pointed scissors, whereby the inter-acromial diameter is considerably reduced. It is, of course, only possible when the child is dead. In cases of difficulty at the outlet due to the shoulders when, for example, the perforated head has easily been delivered, it is a simple matter to pass a pair of scissors just inside the vulva alongside the neck, and to divide each clavicle, but when the shoulders are held above the brim, this may be very difficult.

The scissors are passed in the same way as the perforator, that is, carefully shielded by being enclosed in the left hand. Each clavicle is carefully located and divided. During the actual cutting, the left hand must ensure that no maternal parts, such as a lip of the cervix, are in danger. It is usually impossible to divide the clavicles of shoulders which are held above a contraction ring, owing to the height above the vulva and the tightness of the ring.

EVISCERATION

Certain fœtal deformities of the chest and abdomen causing great enlargement may obstruct delivery, or else the pelvis may be so extremely contracted that it is impossible to deliver the trunk. Occasionally, in impacted shoulders presentations, the operation of decapita-

tion may be too dangerous until the bulk of the child's body has been reduced. Evisceration consists in cutting through the abdominal or thoracic walls with strong scissors and in evacuating the viscera by the fingers. The commonest form of this obstruction is fœtal ascites. If the abdominal wall cannot be reached, it is necessary to cut through the chest wall and then through the diaphragm to evacuate the abdominal contents. If the obstruction is due to a collection of fluid, perforation of the parietes will immediately resolve the difficulty.

CHAPTER V

Primary Repair of the Vaginal Orifice

Under this heading we have departed from the customary use of the word perineum, as it is apt to be misleading. "Repair of the perineum" lays undue stress on the injury to the *perineum*, but, in fact, the inevitable injury of the posterior vaginal wall is just as serious a lesion as that of the external skin and perineal tissues. Further, the use of the word perineum leads to the impression that, if the perineal skin is found to be intact after delivery, no injury has been sustained, but only too often an inspection of the vagina just inside the orifice will show a deep and extensive tear of the posterior vaginal wall. The tendency to this injury is probably encouraged by the practice of delivering the head very slowly in an effort to allow the maximum possible stretching of the perineal tissues. By such slow delivery it is true that the actual perineal skin is saved. but there is often a deep underlying tear, which may not be recognised. In cases of difficulty due to long, slow stretching of the perineum it is much better to make the small incision known as episiotomy whereby both the perineum and vagina, by being cleanly incised, are saved from laceration.

PRIMARY COLPO-PERINEORRHAPHY

After delivery, a careful inspection of the perineum and posterior vaginal wall is made. Blood is carefully sponged away, and under a good light the heavily bruised vaginal wall is searched for a tear. It is often not easy to recognise the limits of the tear, for the tissues are discoloured, and the tear is ragged, irregular, and often multiple. There may be one central injury, or a laceration may extend up each postero-lateral wall. In some cases the perineal and vaginal lacerations may open into each other. A more serious injury may tear the perineum as far back as the sphincter, exposing, but not actually damaging it. In the worst cases the sphincter is broken, and the mucous membrane of the anal canal is torn up its anterior wall for perhaps as much as an inch.

Before inserting any stitches, therefore, it is essential to make a close examination to find out exactly which structures need repair

(fig. 2145). These operations are usually performed under the greatest difficulties. The patient is lying in a soft bed on her left side, the light is often poor, and there is frequently no assistant. Also the field of operation is being constantly obscured by blood, and the limits of the injury of the vagina are not easy to define because of bruising. In a hospital clinic there is no difficulty, but the conditions of a private house may make a correct repair by accurate apposition almost impossible. However, as far as available assistance will allow, it is necessary to have the woman on her back at the edge of the bed, and a good light directed on to the vulva. Plenty of swabs and lotion should be at hand for cleansing the part, and, if necessary, a small plug should be pushed just into the vagina to prevent the lochial blood from constantly flowing over the site of operation. Also, have at hand a vulval self-retaining retractor, No. 2 catgut, silkworm-gut, a few artery clips, toothed dissecting forceps, a needle-holder, large curved cutting needles, and smaller ones for suturing the vagina.

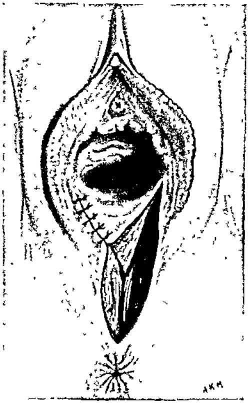


Fig 2145.—Repair of vagina and perineum.

1. *Repair of the Vagina.* The upper limit of the tear—the apex of the V—is held by dissecting forceps and the two edges of the wound are united from above downwards by interrupted sutures of catgut mounted on the smaller needles. In inserting these stitches it is a great convenience to use a needle-holder. The bite of the needle should be deep enough to include the deeper sub-vaginal tissue. After the first one or two sutures are inserted, the limits of the injury become more obvious, and when one tear has been repaired, any other tear also becomes easier to define. The whole vaginal wall, therefore, is repaired as far as the perineum. The reconstitution of the vaginal tube alters the whole appearance of the injury and renders much clearer the work which remains to be done (fig. 2146).

2. *The Perineum.* The extent of the injury varies considerably. If it is so deep as to expose the sutured vaginal wall, a row of three or

four buried stitches of catgut should be inserted to bring together the subjacent tissues (fig. 2147). After this, the skin and subcutaneous tissues are united by silkworm-gut in large needles. It is important not to tie the tissues too tightly, and to avoid leaving dead spaces (fig. 2148).

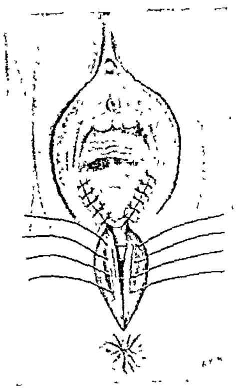


Fig. 2146.—Repair of perineum. The vagina has been sutured, and four deep catgut sutures have been inserted into the edges of the levatores ani muscles.

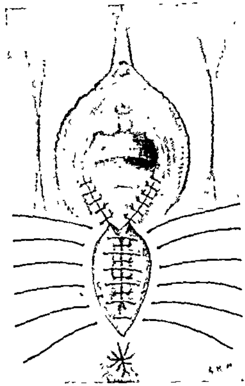


Fig. 2147.—Repair of perineum. Suture of superficial tissues over levatores ani muscles.

3. *The Anus and Rectum.* It is almost impossible to repair injury in this region without every assistance which can be obtained by the lithotomy position and a good light. In addition to the instruments previously mentioned, it is necessary to use round-bodied curved needles and thin No. 1 catgut.

The apex of the tear in the rectum is identified, and a suture of No. 1 gut threaded on a round-bodied needle is passed from the deep aspect (not the lumen) into the submucous tissue, and out exactly below the actual mucous membrane, then into the opposite edge, again immediately below the mucous membrane, and out through the submucous tissue (see fig. 2149). When this is lightly knotted the edges of the mucosa are coapted, but no catgut actually passes through the mucosa itself. If the edges of the tear are ragged, they must be carefully pared with

scissors. Tissue is brought together below the mucosa, so as to leave no dead space, or otherwise a hæmatoma will collect, which is likely to suppurate and break down the wound (see fig. 2150).

The edges of the sphincter are sought for where they will have

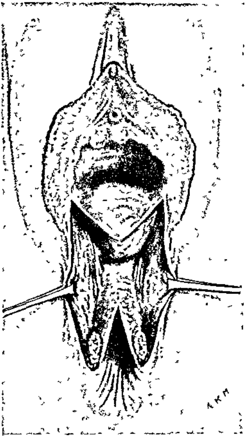


Fig 2148.—Repair of perineum Exposure of wound, with patient on her back to show extent of injury. The figure illustrates a double tear of vagina, complete rupture of perineal body and external sphincter, and tear of rectal mucous membrane.

retracted under the skin, and are sewn together, after which the overlying skin is united with silkworm-gut.

After-Treatment.

If the rectum has not been involved, no special after-care is necessary, except to keep the part clean and dry. After micturition or defæcation the area of stitches should be sponged, dried and powdered. The wound is well healed in about a fortnight, after which the patient may safely get up.

If the rectum and sphincter have been repaired, special care must be taken that, when the bowels act for the first few times, there should be no stretching of the sutured area by hard constipated scybala. To avoid scybalous formation give the patient a teaspoonful of liquid paraffin four times a day after food for the first week. This will ensure that the fæces remain soft, because the small repeated doses are effectual along the whole length of the intestine. On the fourth day the bowels must be moved by giving an aperient such as an ounce of castor oil, and an olive oil enema (4 oz.) about four hours after the castor oil has been taken, or as soon as the patient feels that the castor oil is beginning to act.

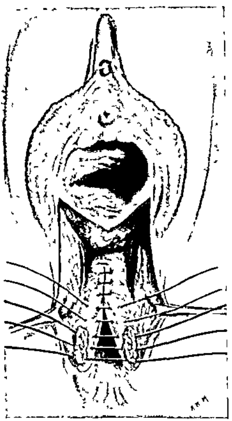


Fig 2149.—Repair of rectum. The stitches of fine catgut are being inserted up to the edges of the mucosa, and three have been tied.

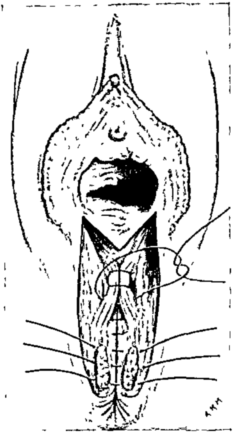


Fig 2150.—Repair of rectum. The mucosa has been united, and the overlying rectal wall is being brought together to cover and support the mucosal layer. Three stitches have been inserted into the sphincter.

During the first week the diet should be limited to milk, milk foods, custards, and potato and other vegetable *purées*.

If a perineal wound breaks down after primary repair no attempt should be made to re-suture it as there is small chance that it will heal well. It is better to cleanse it by hot dressings if necessary, and to perform perineorrhaphy about six months later.

the teachers in the clinics. It is necessary to implant the idea that obstetrics is not a branch of surgery, but an applied science of its own, which requires its own specialised consideration and technique. Certain surgical procedures may be utilised for unusual circumstances when purely obstetric methods would fail, but they should be exceptional and not routine.

As we have already mentioned, the undisputed indication is obstruction to delivery due to pelvic contraction (or disproportion between the sizes of the pelvis and the fœtal head), not only insuperable obstruction, but any degree which is likely to involve the child in danger by excessive moulding or forceps traction. Potential or partial obstructions include various conditions, such as a transverse lie of the child before labour, certain tumours, and the vagina and its outlet being narrowed by atresia, or an over-tight repair operation done for some earlier laceration.

There may be difference of opinion over borderline cases of contracted pelvis, where increasing experience will undoubtedly reduce the incidence of the operation, but the details of this most interesting problem of obstetrics we shall discuss in a later section. Real difference of opinion is possible when we come to discuss associated diseases. The sole question at issue should be whether or not the physical effort of labour is a greater stress, from every point of view, than the abdominal operation, and whether a rapid delivery, as opposed to a protracted labour, will save the mother or child a risk inherent in such labour. There is a tendency to regard normal labour as more dangerous for the mother when some complicating condition such as cardiac disease or nephritis coexists, but it is not possible to apply a rule generally. Each case must be considered on its merits. The great majority of women with cardiac disease tolerate easy labour well, but if labour is likely to be long, painful and exhausting, then the sub-normal reserve of energy will be used up, and the heart will be seriously overburdened. For such cases Cæsarean section is obviously the better treatment. The same considerations may be applied to the consideration of almost every other complication. In general it may be said that, where labour is likely to be entirely normal, the woman suffering from the complication of an associated disease will do better after normal labour than after Cæsarean section.

INDICATIONS IN PARTICULAR

1. *Contracted pelvis.* For the older obstetricians this was almost the only indication. They divided these cases into those whose

obstruction was absolute, and those in whom it was relative. For the first group there was no choice, for the second, induction of labour was an alternative method. Nowadays, we feel that if the disproportion between the head and the pelvis is such that the child runs a risk of still birth by excessive moulding or shock, or that the mother is liable to suffer from exhaustion and laceration with their sequelæ of hæmorrhage, shock and infection, Cæsarean section is the correct method of delivery.

In practice the difficulty is to decide the prognosis of labour. Obstetrics does not offer a greater field for the exercise of clinical insight than the making of this decision. Even after years of observation and experience, every obstetrician will from time to time meet with cases in which he feels doubt, and over which he may be mistaken. The study of this problem is one of the fascinations of obstetrics, and lends to it a scope of clinical interest which can tax the most mature skill and consideration. The essential is to be able to prognose the course of labour in these cases of disproportion. A superficial or inexperienced reading of physical signs before labour will so often give the impression of obstruction or great difficulty in delivery—a prognosis that may be completely falsified by the result of labour. In such cases, not only may a prognosis of obstruction be falsified, but the junior members of the clinic may well be astounded by the extraordinary ease of labour. The quickness of the second stage and the absence of caput and moulding only serve further to surprise those who had predicted difficulty. We have previously stated that it is important to be able to diagnose real disproportion. A sound judgment will save many a woman from an unnecessary Cæsarean section or induction of labour.

An opinion requiring much experience can scarcely be based upon the written directions of a text-book. But it may be of service to suggest a few details for observation. *The operation is indicated under the following conditions :*

(*a*) *If the woman has had a previous still birth due to disproportion.* Here a history of difficult labour is not sufficient. The difficulty may have been due to an unrecognised, and therefore unrotated, occipito-posterior presentation. If the previous child was abnormally large, the probability is that the present child will be even heavier.

(*b*) *When the pelvis, by internal palpation or X-ray mensuration, shows a contraction beyond the "pelvic reserve" of the normal pelvis.* It is not easy to define this in centimetres, but should the true conjugate be less than 3½ inches (9·5 cms.) it is certain that there will be a risk of

excessive moulding and still birth. But with experience, digital examination of the pelvis gives a useful idea of its capacity, and is of more value than exact mensuration. If the sacrum can be palpated all the way up to the promontory, if the lateral walls of the cavity feel nearer together than normal, if the sub-pubic angle is narrow, and if the distance between the ischial tuberosities will not admit more than three knuckles, then the pelvis is probably too small to pass a child of average weight. But, even so, other details must be considered, such as the ease of pushing the head into the brim, and its size and attitude.

If the head is strongly flexed and lying with the occiput anteriorly, it may pass the brim, whereas the same head lying posteriorly and unflexed may be unable to descend.

Real overlapping of the head above the symphysis, if the other conditions also are taken into consideration, is usually a strong indication for Cæsarean section; and even without obvious overlapping of the symphysis, if the head cannot be pressed into the brim, or, if firm pressure on the head imparts no sensation of descent, engagement, or "spring," it is very unlikely that the head will go through. But whatever may be the mechanical conditions, such as size of pelvis and head, we must not forget that the head is moulded and driven through the pelvis by uterine contractions. If these are strong and regular, labour may be completed normally, but if the "pains" are weak and inconsequent, the same head may be unable to pass through the same pelvis. It is not, of course, always possible to prognose the type of uterine contraction, yet a large experience of women and labour, and the recognition of certain female types which may give rise to what Greenhill aptly calls "*dystrophic dystocia,*" will greatly assist in deciding whether or not a borderline case may be trusted to undergo labour. In all such cases labour should be recognised as a test or trial labour, and should only be conducted in a hospital clinic where Cæsarean section can be performed if it becomes obvious that labour cannot be terminated naturally. The most striking feature of trial labour is the large proportion of cases which do terminate naturally.

There is an uncommon variety of contracted pelvis to which allusion must be made here—the transversely contracted pelvis of Van Rooy. This type is not easy to recognise unless one is prepared to find a definite contraction of the transverse diameter and the outlet. Where this condition is definite, we feel that Cæsarean section should always be undertaken.

2. *Placenta prævia.* The treatment of this condition has altered

considerably during the last twenty-five years. There is no question now that where the pregnancy has reached the 36th week, the placenta is central, and the mother is in a good condition (i.e. she is not exsanguinated and shocked) Cæsarean section can be carried out at the price of a mortality of less than 3 per cent, whereas the risk of vaginal delivery of central cases rises to 15 per cent or even more.

If the patient is shocked by loss of blood, the operation must be deferred for some hours, during which she should be treated by blood-transfusion, morphia, and warmth. The rise of blood-pressure caused by transfusion will not induce further hæmorrhage, as in all ordinary cases of arterial bleeding. A recurrence of hæmorrhage is determined only by separation of a further portion of placenta by uterine contractions.

Partial placenta prævia seldom requires Cæsarean section in the interest of the mother, but it certainly gives the child a better chance. Where the edge of the placenta only reaches the margin of the os, it is usually sufficient to rupture the membranes and bring a leg down, or to apply Willett's forceps to the scalp.

Though Cæsarean section is a great addition to the methods of treatment of central placenta prævia, it must be regarded as carrying its own risks. Even when the mother is in good condition when the operation is done, there is a definite mortality. Most of this arises: (i) as a result of operating while the patient is in a deeply shocked condition; (ii) after attempts have been made to arrest bleeding by vaginal interference; or (iii) due to post-partum hæmorrhage after the child and placenta have been removed.

3. *Accidental hæmorrhage* (*abruptio placentæ*). There is not such a wide field for treatment by Cæsarean section as in placenta prævia. The mild cases can be well treated by medical measures or, at the most, by induction of labour by rupture of the membranes, while the severe cases are too ill to withstand the shock of laparotomy. These patients are always ill, apart from the effects of loss of blood, and actual delivery is not all they require. We would say that the operation should, as a rule, only be done for accidental hæmorrhage if the patient is carrying another handicap in the shape of contracted pelvis or malpresentation, in addition to the condition which has caused bleeding.

4. *Eclampsia.* Most authorities now agree that Cæsarean section is rarely indicated for eclampsia. For adequate treatment it is necessary that the uterus should be evacuated, but it is not only *not* necessary that this should be done rapidly and at once, but it is true that so doing is liable to add an extra burden of shock, or some other adverse influence,

which may tip the scale against the patient. There are, however, exceptional cases for which rapid delivery may offer the better chance. Any additional abnormality which may render vaginal delivery difficult should influence consideration in favour of Cæsarean section. For example, there may occasionally be great œdema of the vulva, an elderly primigravida with a tightly closed cervix before pains have begun, and certain other conditions which, being present, would either delay vaginal delivery or, which is most important, require much manipulation through the vagina. There is also room for discussion over the fulminating case, or the woman who sinks into toxic coma with suppression of urine, with perhaps no fits at all. The outlook for these women is extremely bad, and little can be expected of the operation for the mother, although it is possible that rapid delivery may save the baby.

5. *All serious obstructions likely to be offered by the soft parts are adequate indications.* Such a list includes atresia, firm repair of the perineum, and a long, hard, tight cervix in an elderly primigravida. Under this heading may also be included tumours in the pouch of Douglas below the presenting part which cannot easily be pushed up, certain cases of cancer of the cervix, and, very rarely, a cervical fibroid.

6. *There is an undefined group of women who have had previous obstetric difficulties with perhaps one or more still births.* Greenhill has well described dystrophic dystocia as a form of difficult or ill-fortuned delivery which is inherent in the woman herself, and may be anticipated in every labour. Or again, a woman may be liable to hæmorrhage, either before or after labour, recurrent adherent placenta, habitual death of the child before full term, and many other conditions, which are met with from time to time, and must be considered, each on its merit. A healed vesico-vaginal fistula, after perhaps more than one operation for its closure, should always be an indication for the operation, because distension of the vagina by the head is very liable to break down the repair.

7. *Associated diseases*, including cardiac and pulmonary diseases, nephritis, and many others, form a large group about which there are many opinions, even on an individual case. The general principle which should govern consideration of every case is whether or not the stress of labour will be greater than that of laparotomy. Usually a normal straightforward labour involves less strain on the woman than Cæsarean section, but any departure from the normal, such as pronounced inertia, may be a serious danger. This is well seen in heart disease. Women who are subjects of a degree of heart disease which

has caused a temporary breakdown during pregnancy stand a normal, quick, and assisted delivery without any striking difficulty, but if such a woman should suffer from long, painful inertia she becomes quickly exhausted and her condition is dangerous.

8. *Some fœtal conditions*, including prolapse of the cord at the beginning of labour, or a malpresentation which cannot be corrected and is dangerous, may properly be treated by Cæsarean section. Habitual death of the fœtus before term may be treated in a succeeding pregnancy by operation performed at the 36th week.

9. *A previous Cæsarean section is not necessarily an indication for all further deliveries by this method.* If the original indication was a contracted pelvis, a healed fistula, or any other condition which is inherent, then obviously the operation will be necessary for every future delivery. If, however, the indication was placenta prævia or anything which is not liable to be repeated, then a second Cæsarean is not necessary simply because the uterine wall has been scarred. But if it is probable that the scar is thin from imperfect healing due to sepsis at the time of the previous operation, then it is safer to deliver all subsequent children by Cæsarean section. This applies especially to the upper segment or classic operation. If the muscle union of the scar is imperfect because of healing by granulation in the presence of infection, rupture of the scar during labour is probable, but a similar degree of "thinning" of the scar of the lower segment operation does not offer anything like the same danger. The general considerations are the position of the scar, and the existence of fever, and therefore presumably infection during the puerperium which followed the previous operation.

CÆSAREAN SECTION DURING LABOUR

Whereas the mortality of the deliberate operation done before labour, or at its very onset before rupture of the membranes or vaginal examination, is low, not more than 1 per cent or 1·5 per cent, it rises when it is performed after the membranes have ruptured, and it rises sharply after efforts have been made to deliver by the vagina. Since the widespread adoption of the lower segment method, this statement needs modification, for experience has shown that even in the presence of infection the risks are not so great as for the old classic operation.

During labour, Cæsarean section for a live baby competes with craniotomy when the child is moribund or dead, and the indication is nearly always contracted pelvis, though not uncommon difficulties are rigidity of the cervix or inertia, prolapse of the cord or certain malpresentations. The operation is therefore proposed for the sake

of the child, because only in severe cases of contraction will craniotomy be sufficiently difficult to cause risk to the mother's life.

If the labour is a so-called *trial or test labour*, every care will have been taken, firstly, to avoid vaginal contamination, and, secondly, not to delay operation until the child has been distressed. In these conditions the end-results are likely to be as good as when the operation is done before labour begins. But it is a very different matter if the woman has been examined several times, or if forceps have been applied. The danger of infection can only be justified if the condition of the child is good enough to promise a live birth. It is necessary here to point out that, even if the child is in good condition, as judged by its heart sounds, it does not follow that it will survive a Cæsarean delivery. After a long labour following rupture of the membranes or a failed attempt at forceps delivery, the condition of the child is not so good as the heart sounds would suggest. The child suffers a definite degree of shock by abdominal delivery, and if it has already been stressed by labour and forceps, the chance of survival is poor. It is not justifiable, therefore, to subject the mother to the grave risk of Cæsarean section for the sake of a child which is likely to be still-born.

It may be said now, in the light of experience of the lower segment operation, that the classic operation is quite unjustifiable after the membranes have ruptured. Whereas the mortality is about 1 per cent when the operation is done for contracted pelvis before labour, after the membranes have ruptured and forceps have been applied it rises to the region of 28 per cent.

COMPARISON OF UPPER AND LOWER SEGMENT CÆSAREAN SECTION

There is no doubt that the classic operation is easier and quicker to perform. It can be done comfortably by most operators in 20 minutes or less, and there is no risk of injury of viscera or large vessels. The writer believes that there is still a field for this method, though in many clinics it has been entirely discarded. The chief indications are: intervention before labour has begun, that is, before the lower segment has been pulled up and defined anatomically, and if sterilisation is to be carried out at the same time. The chief disadvantage of the fundal incision, namely, rupture of the scar in future pregnancy or labour, will not therefore be a consideration. It is also a safer operation for the inexpert or occasional operator, as it demands no knowledge of anatomy, and there is no danger of visceral injury.

There are, however, many counts against the upper segment Cæsarean section. The chief is the risk of subsequent rupture of the

uterine scar. Holland gives the figure of 4 per cent. K. M. Wilson (*Am. Journ. Obst. and Gyn.*, 1926 xii, 268,), in reviewing 133 pregnancies after Cæsarean section, found 3 ruptures out of 39 women who had subsequent labour, of whom one died. Twenty per cent of the cases of rupture occur between the 7th and 8½th month (Findley, *Am. Journ. Obst. & Gyn.*, 1916, lxxiv, 411). Pulmonary embolism is much commoner after the upper than after the lower segment operation. Phaneuf (*Am. Journ. Obst. and Gyn.*, xxi, 1931, 498) describes a mortality of 3·7 per cent due to embolism after the classic, and 1·2 per cent after the lower segment operation. The writer's mortality from embolism is 1 death out of 209 upper segment operations, or 0·47 per cent (total mortality of all cases 3·2 per cent, mortality of non-urgent cases 1·4 per cent).

Other risks are intestinal adhesions and obstruction, either during the convalescence or during later years (the writer's results show 0·47 per cent mortality from this cause); adhesion of the uterus to the abdominal wall with the occasional formation of a uterine fistula; peritonitis if the uterus is opened during labour in which infection has developed before operation; and any of the complications which may follow laparotomy, e.g. ileus, pneumonia, bronchitis, and sepsis of any form.

The great advantages of the lower segment operation are that the incision in the visceral peritoneum is made low down in the utero-vesical fossa, where the risk of spread of infection is at a minimum, and where intestinal adhesions are unlikely to develop; secondly, that the uterus is incised in a part of its wall which is comparatively inactive during labour, and therefore less likely to rupture, a part which heals well, and is away from the placental site. This operation has been developed as a result of the search for a safe method of delivery during the course of labour, even if it is actually infected. The high mortality of the classic operation in these conditions rendered it unjustifiable, with the result that children were lost, and the mothers were subjected to long and lacerating delivery, perhaps after destructive fœtal operations. The lower segment operation is a great step forward, as is shown by the results of all clinics which have published their results. Phaneuf (*Am. Journ. Obst. and Gyn.*, xxi, 1931, 498) reports on the end-results of 418 operations. He reports a mortality of 5·6 per cent for the intra-peritoneal operation with the longitudinal incision, and 3 per cent for the transverse incision. Of these cases (358) 154 had been done after labour began, and 41 after the membranes had ruptured. He also reports no rupture of the scar in 14 patients who had a subsequent labour, and no adhesions in 105 cases which were operated upon again at a later date.

Skeel and Jordan (*Boston Obst. Soc. Proc.*, Nov. 20, 1934) have collected 2753 cases of lower segment operations with a mortality of 2·5 per cent (compared with a total mortality of 5·2 per cent in 3468 upper segment operations). Of these patients, 56 per cent were in labour, some for many hours, and 25 per cent had had the membranes ruptured. Greenhill reports the mortality rates as follows: classic operation, 147 cases—4·76 per cent, lower segment operation, 874 cases—1·26 per cent. He states (1930) that the entire literature records only 22 cases of rupture of the lower segment scar, of which 18 operations were done during labour.

All the evidence goes to show that the lower segment is the safer route, and that by this incision the scope of Cæsarean section is extended to include treatment of patients who have been in labour for some hours, even after the membranes have been ruptured. The special scope of the operation is therefore as a means of completing trial labour where vaginal delivery proves to be impossible, and where every care is taken to avoid septic contamination.

But despite the enthusiastic accounts of the operation, chiefly from America, it is necessary to add the warning that, no matter what may be the method and technique, it is still highly dangerous to open the abdomen and the uterus in the presence of streptococcal infection. Not only is it of great danger to the life of the mother, but it puts her to the risks of sloughing abdominal wall, vesico-vaginal fistula, chest complications, and usually of a dead baby.

Trillat of Lyons (*Bull. de la Soc. d'Obst.*, 21, 697, Nov. 1932) calls attention to the dangers of the lower segment operation when the uterus is infected. He reports the following figures:

	No.	Dead.	Percentage Mortality.
Non-infected . .	43	1	2·3%
Suspect . . .	53	3	5 6%
Febrile . . .	14	4	28·5%

He also shows the malign influence of ruptured membranes as follows:

	No.	Dead.	Percentage Mortality.
Non-ruptured . .	43	1	2·3%
Up to 12 hrs . .	32	2	6·1%
12 to 24 hrs . .	11	1	9 0%
Above 24 hrs . .	12	4	33·3%

These figures are not materially different from those of the fundal operation in the main lesson they teach.

Uterine scar. Many examinations of the uterine scar have been made at subsequent Cæsarean section. The fundal wall unites with perfect muscle-to-muscle union, provided it is sutured well and there

is no infection. If, however, the uterus is infected there will be a layer of granulation tissue between the muscle surfaces which will result in the formation of fibrous scar tissue (fig. 2151). The whole thickness of the muscle will fail to unite in parts, and in some places it may fail altogether, so that the peritoneum may come to lie in contact with the

Fig. 2151.—Uterine scar. Note the fibrous tissue uniting the edges of the muscles

Fig 2152.—Uterine scar. Muscle union has failed, and the decidua and peritoneum are in contact.

decidua (fig. 2152). It is rare for such extreme failure of union to exist along the whole length of the scar, but at intervals the scar will show deep dimples or "digital fossæ" where the peritoneum and decidua are in contact.

In the case of the lower segment the union is said to be more certain. After examining 37 specimens of scars of the lower segment incision Greenhill found results as follows:

Complete muscular union	6
Small islets of connective tissue	5
Abundant areas of connective tissue	21
Extreme "thinning" of the scar	5

"Thinning" of the scar is a very common condition, but while in the upper segment it is highly dangerous, it seems to be of much less importance in the lower segment. Ordinarily the scar shows three layers: (1) A band of "sclerotic" (fibrous) tissue; (2) a band of muscle tissue dotted with islets of fibrous tissue, probably representing the catgut suture prints; and (3) a band of normal muscle.

The causes of malunion of the lower segment incision are inclusion of islets of mucosa in the muscle stitching, formation of small hæmatomata, imperfect suture and suture material, and infection. As we might expect, the scar after incision for placenta prævia gives the highest rate of ruptures. Trillat records that of 26 ruptures 8 followed lower segment operation for placenta prævia. Greenhill divides his 37 cases into four groups according to firmness of union, and classifies them as follows:

Group 1.	"Perfect union"	6 cases
Group 2.	Mild scarring, but not enough to interfere with contraction of muscle	5 cases.
Group 3.	Much fibrous tissue, occasional distinct thinning of the scar	21 cases.
Group 4.	Great thinning; in some cases scar was less than 1·2 mm. thick ($\frac{1}{10}$th of the normal thickness)	5 cases.

From this study of scars Greenhill concludes that the conditions tending to produce a bad scar are:

1. *The operation having been done after labour has been progressing* for a long time.

2. Presence of infection, as shown by fever during the convalescence. Rupture of the membranes had, however, of itself no influence. The use of interrupted catgut sutures is better than the use of a continuous stitch.

We may sum up, therefore, by saying that imperfections of the scar of the uterine incision are of much less importance in the lower than in the upper segment, as judged by the tendency to rupture. If, therefore, Cæsarean section has to be done in the presence of infection, there will be a greater chance of obtaining a functionally good scar in the lower segment, even if there are anatomical defects. When this is added to its other recommendations it must be agreed that, as a general rule, the lower segment operation is the one of choice.

TECHNIQUE

A. *Upper Segment Cæsarean Section*

1. *Preparation of the patient and theatre.* The patient is prepared as for any simple abdominal operation. There are many modifications of procedure according to individual operations. An ordinary practice is to fix the operation for a time a few days before the expected date of labour. An aperient is given two days before, and an enema on the night before. The belly wall is shaved, washed, and painted with 2 per cent tinct. iod. in alcohol during the previous evening, and it is again painted before making the incision. A catheter is passed immediately before coming to the theatre.

There is no need to describe the theatre requirements when the operation is carried out in a hospital or private clinic, beyond stating that, in addition to the operating table, a table is needed for instruments, another to hold sterile dressings and bowls of hot saline, and a third to carry the requirements of the child—eye swabs, cord ligatures, coramine or other stimulants, and a syringe.

The surgeon employs an assistant who stands opposite, a nurse to preside over the instrument table, a nurse who shall not be surgically sterile, and a nurse whose sole duty it will be to receive the child and minister to its needs. As the child delivered by Cæsarean section is often apnœic, many obstetricians like to have a bath ready for the baby, but nowadays most of us have discarded the bath and only ask that the baby should be wrapped in a warm blanket and held quietly with its head low.

2. *Anæsthesia.* In this country the administration of anæsthetics has reached such a generally high standard that we are largely independent of local anæsthesia; but on the continent of Europe and in America local anæsthesia is still widely used. The chief point is that the minimum quantity of anæsthetic should be given before the baby is released. The ideal combination is gas and oxygen with a small admixture of ether. After the child is delivered, the ether may be pressed if a greater depth is required. No pre-operative medication, such as morphia or the barbiturates, should be given, on account of the child, but a $\frac{1}{150}$ grain of atropine, half an hour before the scheduled time of operation, is useful for checking the secretion of pulmonary mucus. The combination of gas and oxygen with ether is so satisfactory that it may well displace time-wasting methods of local anæsthetic injection. Spinal anæsthesia is very often used as, by its effect on the lumbar cord and uterine muscle, uterine contraction is encouraged. It is not advisable in cases of heart disease, or in most cases of associated illness, but for the deliberate operation spinal anæsthesia has much to recommend it.

3. *Operation.* An incision of about 6 inches long is made in the middle line, or, better, just to the right, having about 2 inches of its length above the umbilicus. The object of placing the incision high up is to ensure that the abdominal scar shall not overlie the *uterine wound to which it may become adherent.* The abdominal wall is often very thin, and care must be taken not to cut through too quickly lest any adherent gut be wounded. Having opened the abdomen, wrap the edges of the wound with a large swab on each side, tucking it well under the deep surface. In this way the whole surface of the wound and skin is covered. A hand is passed to the cornu of the uterus to find out how much the uterus is rotated to the right. This is then pulled over to the left in order to ensure that the incision in the uterine wall shall be central. Unless allowance is made for the torsion to the right, the incision may lie near the left cornu, and enter the uterine cavity by an oblique cut through the muscle. The uterus therefore is central, and the abdominal cavity has already been well packed off to prevent the spill of liquor amnii and blood into the peritoneum. For the uterine incision a fresh knife is taken to avoid infection by a knife which has already cut skin. It is often thought that the uterus must be incised quickly and the child extracted as rapidly as possible. This is quite unnecessary and wrong. If incision of the uterine wall is hurried it cannot be cut cleanly, and subsequent apposition by suture must be imperfect. By a succession of strokes of

the knife the whole thickness of the muscle is divided. After each stroke the assistant rapidly and firmly swabs in the wake of the knife. From the more superficial layers, i.e. during the first two or three strokes, the bleeding is usually free, especially if the placenta is underlying. But such bleeding is of no importance, and it should not induce one to hurry. While making the incision, care should be taken to extend it to each extremity. The whole length of the wound should be incised to an equal depth. It is important not to make the deepest part in the middle, as otherwise the extraction of the child will cause tearing of both upper and lower angles, difficult suture, and imperfect union.

As the knife steadily and deliberately divides the decidua, its edges yield apart by the protrusion of the amnion through the incision. A few delicate strokes of the knife are then made at each extremity to divide the last strands of the muscle and the decidua, so that the whole length of the incision has been utilised for exposing the amnion, or, often, the placenta. If the amnion is subjacent, there is very little bleeding at this stage, and the cleanly cut muscle edges fall away for as much as 2 inches in the middle, with the amnion projecting between. If the placenta presents, it is not so easy to recognise when the muscle has been entirely divided. But though there is much more bleeding when the placenta is on the anterior wall, care should nevertheless be taken to divide the whole thickness of the muscle from end to end.

The hand is then passed through the amnion or round the edge of the placenta to find one of the feet. This is grasped, and the child is quickly extracted and held up by its foot for a few seconds while two artery clips are placed on the cord. The cord is divided immediately, and the child is handed to the nurse who is standing to receive it in a sterilised towel. Meanwhile the assistant has pulled the fundus out of the abdomen and stuffed a large swab into the abdominal wound above the fundus to prevent the escape of coils of gut. He then takes a large towel wrung out of hot saline and wraps it around the uterus, and holds it firmly; but he should not exert any hard grip, nor should he attempt to remove the placenta while the surgeon is busy with the child. Having handed the child to the nurse, the surgeon returns to the uterus and removes the placenta and membranes. If the placenta has underlaid the incision it is a simple matter to continue the separation by inserting the hand between the placenta and uterine wall and, with a gentle sawing movement, complete its detachment. The membranes are usually easily peeled off as the placenta is gently and slowly drawn away. Great care must be taken to see that the chorion is removed

from the lower segment, and especially over the os, or the lochia will be retained. The lower segment cannot be easily inspected as it is below the incision, in darkness, and concealed by blood. Finally, the finger is passed just through the internal os, partly to dilate it, and partly to ensure that if any chorion is overlying the os, it is broken. A small fragment of chorion left attached to the lower segment is not of great importance, and need not delay the operation.

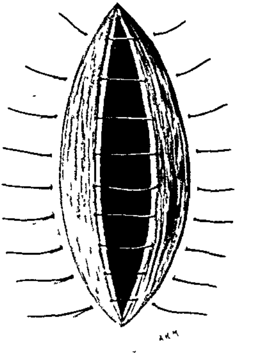


Fig 2153.—Suture of uterine wound by the first layer. Silkworm gut sutures passing through the muscle, down to, but not through the decidua.

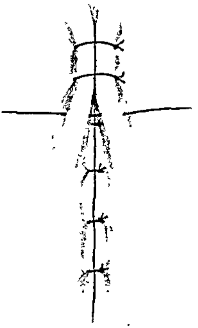


Fig 2154.—Suture of uterine wound. The insertion of the second layer of sero-muscular catgut stitches.

Suture of the Uterine Wall. There are several methods of suture. The writer has practised the same method for many years, and has no reason to alter it because of bad results. This method will therefore be described in detail.

Ease and rapidity of suture will depend to some extent on how the uterus is held by the assistant. He places each hand over a towel flat on each side of the fundus, thereby compressing the walls and retarding bleeding. The cut surfaces of the muscle then face upwards to the operator, inside the radial borders of his hands. A silkworm-gut suture mounted on a large, curved cutting needle is then entered near the lower angle of the wound at the very edge of the peritoneum fairly deeply into the muscle, down to, but not including the decidua

(fig. 2153). It is most important not to encroach on the decidua. The needle is entered on the other face of the incision just superficial to the decidua, and, with a similar bite of the muscle, brought out at the edge of the peritoneum (fig. 2154). The assistant then turns the cut surfaces of the incision inwards towards one another to bring the cut peritoneal edges together, and the silkworm-gut is tied fairly tightly by a double knot. The surgeon himself then cuts the gut close to the knot. A second needle is taken and inserted about 2 cms. (or $\frac{3}{4}$ inch) from the first, and tied. In this way the whole incision is closed by a row of interrupted silkworm-gut stitches. As the upper angle of the wound is approached, it is not possible to tie the penultimate stitch until the last has been inserted. When the first row has been inserted the whole fundus is enclosed by a hot wet towel and compressed for a few seconds, and a

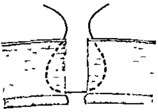


Fig. 2155.—Suture of uterine wound. A vertical diagram of insertion of the silkworm-gut suture.

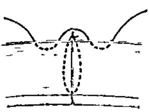


Fig. 2156.—Suture of uterine wound. Vertical diagram of the insertion of the second layer of catgut stitches.

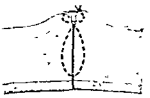


Fig. 2157.—Suture of uterine wound. Diagram of the knots tied. In the figure, the second stitch — sero-muscular — has not been tied tightly enough to bring the peritoneal surfaces into apposition.

dose of 5 units of pituitary extract is given. If it is given at an earlier stage, it may induce such strong contraction as will make the subsequent sutures " cut out."

The next and last line is a row of interrupted No. 1 catgut sutures inserted by a round-bodied, curved needle. The needle takes a Lembert bite of peritoneum and muscle on each side of the incision, at intervals between the silkworm-gut knots (fig. 2155). A further number of similar sutures is then placed over the knots (fig. 2156). By this means the silkworm-gut is entirely buried, and the thickness of the uterine wall is built up along the incision (fig. 2157).

After further pressure through a hot towel, the uterus is dropped back into the abdomen, and the utero-vesical pouch and other pockets are carefully and gently swabbed clean of blood and liquor amnii. If the uterus has been soft and flabby during the time of suture, it should be compressed in a towel from time to time, but however soft it has been, it nearly always contracts well as soon as it has been replaced.

The abdominal wall is then closed in the usual manner.

Alternative methods of suture of the uterine wall are by the use of three layers of catgut, either interrupted or continuous. The continuous suture has the objection that, as the length of the incision rapidly diminishes with involution, the catgut will become slack. This has been obvious at post-mortem examination during the puerperium. An objection to catgut is that it tends to be quickly absorbed by the autolysing muscle, and that its sterility cannot be entirely guaranteed. Thread and silk are definitely bad suture materials on account of the difficulty of ensuring sterility. Silkworm-gut can be guaranteed sterile, it is not absorbed, and it does not cause irritation of the surrounding tissues.

Holland's review of the cases of rupture of the uterine scar showed that the majority had followed the use of catgut, while there were no reported cases following silkworm-gut.

Sterilisation. For some patients sterilisation is advisable; for example, after a third Cæsarean section, or for certain associated diseases such as cardiac disease and nephritis. There are other cases also, where the indications are not so tangible, and where the patient may not care for the adventure of a repeated operation, for whom sterilisation would appear to be justifiable. The propriety of this measure will depend on many factors apart from medical details, not excluding religious and moral influences. It is important to assume a fairly rigid attitude and, while having due regard for real considerations, even if not strictly medical, we should refuse to sterilise a woman unless it seems likely that the reasons advanced to-day will be permanent.

The most certain method is bilateral salpingectomy. The important point is to excise a small piece of the interstitial portion of the tube at the cornu by a wedge-shaped incision, and to sew the edges well *together so that the tubal opening is completely buried. Unless the* opening is well covered, sterilisation is not certain. Mere ligation of the tube with silkworm-gut is useless, and so also is resection of a loop of the tube without burial of the uterine end.

After-Treatment. No special after-treatment is required beyond that for any laparotomy. The best aperient is castor oil. It should be taken after forty-eight hours, and should it be delayed in action, an enema is given. If flatulence is painful during the first two days, a turpentine enema can be given at any time.

The child should be put to the breast after twenty-four hours, and breast-feeding should be encouraged. The patient is seldom troubled with post-anæsthetic vomiting, and can therefore take solid food the next day. She should be allowed to get up on the 16th day if all is going well.

Complications. The sequelæ which are liable to follow the classic Cæsarean operation are flatulence, ileus, and even organic obstruction

due to a coil of small intestine becoming adherent to the uterine wound. Septic complications are very rare after the deliberate operation. If it has been performed upon an infected patient, sloughing of the abdominal wound, infection of the uterine wound, adhesion to the parietes, and peritonitis may all occur. In addition, these unfortunate patients are liable to septic pneumonia and its results. Acute dilatation of the stomach is not uncommon, particularly in the timid, nervous type. It shows itself after 48 hours by gastric distension, prostration, and the characteristic spurts of vomiting. Flatulence is usually overcome by enemata, either turpentine or ox-gall, combined with a simple carminative medicine. Paralytic ileus is much more serious. There is great dehydration by leakage of fluid into the gut, and prostration. If the ordinary measures for the milder cases fail, give prostigmin 5 cc. intramuscularly. Its results are remarkable. Within 6 minutes the bowel usually acts vigorously, discharging large quantities of flatus for an hour or more. In cases of peritonitis the abdomen must be opened and drained, though the outlook is almost hopeless.

B. *Lower Segment Cæsarean Section*

The patient should be in the Trendelenburg position. The incision is 6 inches long from the umbilicus to the pubes in the middle line. When the edges of the abdominal wound are retracted the lower segment and bladder are well exposed. The actual upper boundary of the lower segment is given by the limit of loose attachment of the peritoneum, which, after labour has been in progress some hours, has been pulled well up towards the umbilicus. The greater definition of the lower segment by the action of the fundal contractions renders the operation much easier than before labour has begun. The whole of the peritoneal cavity above and to the sides is well packed off by swabs. This closure of the cavity to contamination is one of the essential features of the operation. Some operators try to achieve the same object by stitching the visceral to the parietal peritoneum, but this takes longer and is probably not so efficacious.

Having exposed the field, note the line which defines the area of loose attachment of peritoneum covering the lower segment from that which is closely applied to the fundus (fig. 2158). It runs transversely across the uterus and marks the limits of the two segments. The loose peritoneum is incised transversely, about 1 inch below the line of its lower attachment, as far as the limits of the exposure. No vessels will be cut at this stage. The lower flap is easily raised, by finger dissection, carrying the bladder with it (see fig. 2159). The separation is

easy, but as the lower limits are reached, large veins may be opened at the lateral parts of the wound. These are caught and ligatured. The edge of the peritoneal flap is stitched to the lower angle of the abdominal wound to hold it out of the way. The upper flap is similarly pushed up to the limit of its loose attachment. and now *the lower segment is completely exposed.*

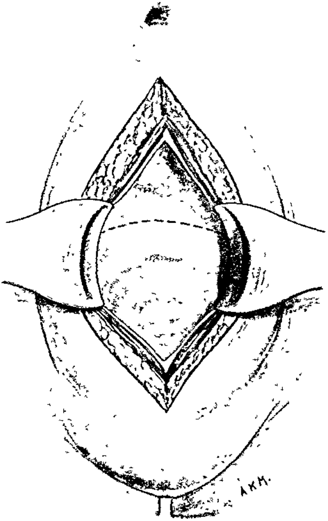


Fig 2158.—LOWER SEGMENT CÆSAREAN SECTION. THE ABDOMINAL WALL HAS BEEN OPENED (PACKS AND SWABS ARE NOT SHOWN) AND THE DOTTED LINE INDICATES THE LINE OF INCISION OF THE UTERINE PERITONEUM AT THE UPPER PART OF ITS LOOSE ATTACHMENT. IN THE FIGURE IT HAS BEEN PLACED A LITTLE TOO HIGH

Choice must now be made between a transverse and a longitudinal incision into the uterus. Most operators favour the transverse. It is difficult to find room for the longitudinal incision wholly within the anatomical limits of the lower segment before it has been pulled up by the contractions of labour. It is therefore very easy to extend the incision, or it may tear into the upper segment as the child is being withdrawn, and it is this encroachment into the upper segment that

has probably been responsible for such ruptures of the scar as have followed the lower segment operation. On the other hand, it is easier than the transverse section, and does not risk the division of the large veins at the lateral extremities of the transverse incision. The choice of incision should meet each individual case. If the woman has been in labour long enough for the lower segment to have been pulled up well, there is sufficient space for the longitudinal incision to be entirely confined to the lower segment, but if the operation is done before the onset of labour, the transverse incision is the more convenient (fig. 2160).

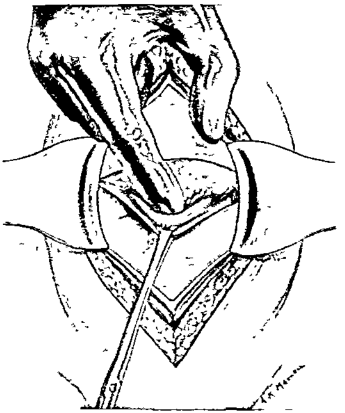


Fig. 2159.—Lower segment Cæsarean section. The peritoneum has been excised, and the lower flap is being pushed down by the finger.

Before incising the uterus, some preparation must be made for removing the blood which wells up in the deep utero-vesical space. The best method is the vacuum sucker which is found in most modern theatres, but if this is not available plentiful large absorbent packs must be at hand. A good Trendelenburg position is helpful at this stage as it allows the blood to flow away from the site of incision. One of the most important details of the technique of the lower segment method is the successful management of the effused blood and liquor amnii. This operation is done, amongst other things, in place of the classic operation, to avoid infection by contaminated liquor, and if this is allowed to spill

into the general peritoneal cavity the advantage of the sequestrated area of the lower segment is lost. Every care, therefore, must be taken in the disposal of the spilt liquor. We should not be going too far if we said that the skill and experience of the surgeon, apart from the prognosis of the operation, would be more apparent from the way he dealt with the effusion than with the actual steps of cutting and suturing.

The Incision. We will describe the transverse incision, as this is generally preferable. Some operators define the lateral limits of the

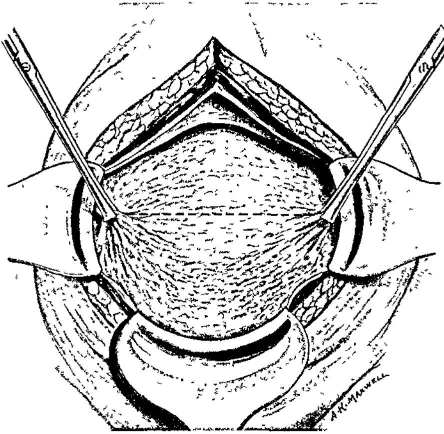


Fig. 2160—Lower segment Cæsarean section The peritoneum has been pushed up and down, exposing the muscle The dotted line shows the usual transverse incision through the muscle although occasionally a curved incision, with convexity downwards, may be used.

incision by two catgut stitches, passed deeply into the muscle, with their ends left long. They may assist in hæmostasis, and also in preventing the wound from tearing into the lateral area of the uterine wall. Or, instead of sutures, tissue forceps may be used.

Having, therefore, made every arrangement for the absorption of "spill," and defined the limits of the incision, make a transverse cut along its whole length, repeating the stroke carefully until the amnion is reached. Usually the amnion is divided as the last stroke is made through the muscle, for the wall is much thinner than that of the upper

segment. Bleeding easily obscures the wound and makes it impossible to see clearly how deeply the muscle is incised until the child's head comes into view. Another method (described by De Lee) is to make a small hole into the uterus at one end of the incision and then pass a pair of intestinal clamps, one on each side of the intended track of the cut, along its whole length. The clamps grip the muscle walls and prevent bleeding. The rest of the incision is completed by passing one blade

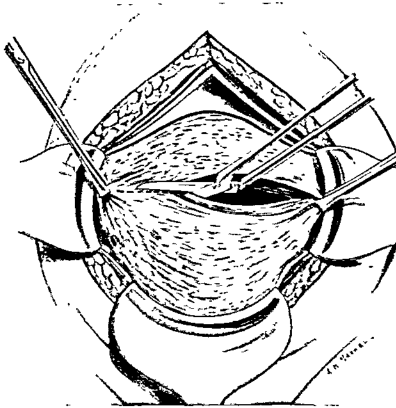


Fig. 2161.—Lower segment Cæsarean section. The incision into the uterine cavity is being made by scissors instead of by successive strokes of the knife.

of a pair of scissors through the preliminary opening, and cutting along the whole length (fig. 2161). Obvious large sinuses are then grasped by tissue forceps, and the clamps are removed.

Extraction of the Child. The occiput or parietal bone usually presents. The simplest method is to lever the head out of the incision by passing one blade of the obstetric forceps round and underneath (fig. 2162). The head is thus easily raised out of the wound, and the whole body slowly removed, first one shoulder and arm and then the other. As the head is the first part to be delivered, there is no need for subsequent hurry. Some operators apply both blades to the head and deliver the head by the ordinary method of forceps extraction. If

this is done, care must be taken to see that the head is rotated to bring *the occiput to the front.* This can be effected by traction on the scalp with a pair of tissue or Willett forceps. If the face presents it can be extracted by hooking a finger in the mouth combined with a little pressure on the sides of the lower segment. If the child's body is removed slowly after the head, time can be taken in sponging the eyes and clearing the mouth of mucus. Also the uterus has time to contract down.

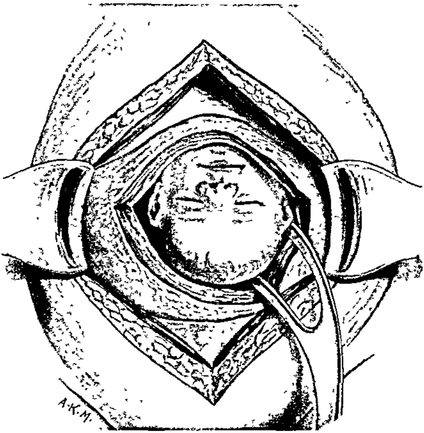


Fig. 2162.—Lower segment Cæsarean section. The head is being levered out of the lower segment by a blade of the forceps.

The Placenta. Immediately the head has been delivered the nurse injects a dose of 5 units of pituitary extract. If the edges of the wound are bleeding freely from any obvious sinuses, toothed forceps such as small vulsella are applied. Do not use a crushing clip like the ordinary artery forceps, or the muscle at the edge of the incision will be damaged. After a few moments the contracting fundus will have begun to separate the placenta and push it down into the wound. This may be encouraged by a little pressure through the abdominal wall, but it is inadvisable to compress the fundus directly as this means soiling the abdominal cavity which we have taken so much care to avoid doing. Nor is it good to pass the hand into the uterine cavity and remove it manually, although if

the separation is sluggish this may be necessary. It is better than removing the "walling-off" packing and passing the hand up into the abdomen to grasp the fundus.

Suture of the Wound. Use interrupted No. 3 catgut. The muscle wall of the lower segment is covered with a thin layer of fascia, and on its deep surface there is the decidua. Pass the first row of sutures through the thickness of the muscle only, avoiding both the fascia and decidua, and place them about ½ an inch apart (fig. 2163). A

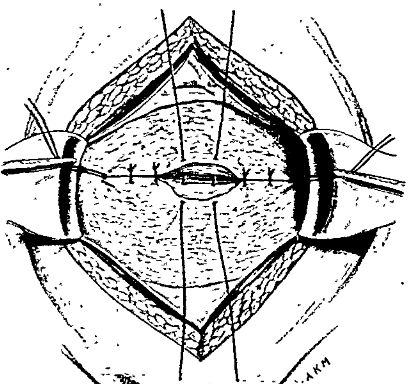


Fig. 2163.—Lower segment Cæsarean section. Insertion of first row of catgut sutures. The figure shows them passing superficial to the subjacent decidua.

few extra ones may be inserted afterwards to stop any bleeding. It is important to avoid the formation of a hæmatoma. It is well now to put in a second row of muscle stitches over the first, to cover the first row, using a fine No. 1 catgut (fig. 2164). The fascial covering is next united by interrupted thin catgut sutures, and finally the peritoneum is approximated by a continuous suture of fine catgut (fig. 2165). After all the stitching is complete, mop away gently every drop of blood, vernix and liquor amnii, carefully remove the swabs which packed off the abdominal cavity, change the gloves of both surgeon and assistant, and sew up the abdominal wall with a fresh set of instruments.

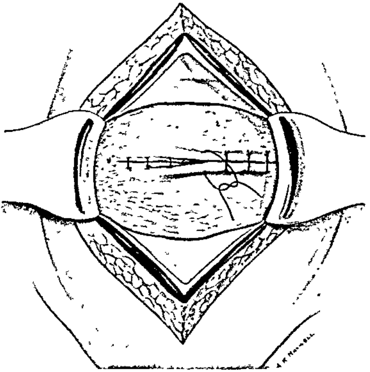


Fig. 2164.—LOWER SEGMENT CÆSAREAN SECTION. INSERTION OF SECOND ROW OF CATGUT STITCHES

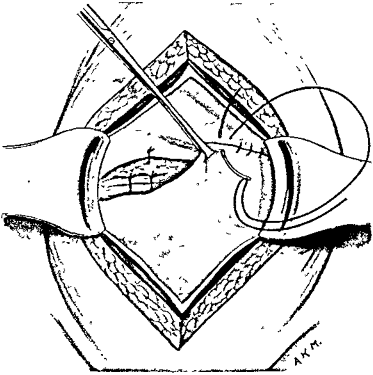


Fig. 2165.—LOWER SEGMENT CÆSAREAN SECTION. SUTURE OF THE PERITONEUM.

C. *Porro's Operation*

Porro devised his operation in 1877 to avoid the mortality due, in those days, to hæmorrhage and infection. It consists in removing the child through the fundal incision, leaving the placenta *in situ*, removing the uterus by the supra-vaginal amputation, and stitching the stump outside the peritoneum to the lower angle of the wound. The essential step is the last. To avoid the risk of contamination of the peritoneum. Porro felt that the stump should be extra-peritonealised.

It is still sometimes necessary to remove the uterus (Cæsarean hysterectomy), e.g. for fibroids, very occasionally for abruptio placentæ (accidental hæmorrhage) where the uterine wall is in a pathological condition and unable to contract, and also for certain rare cases of dangerous infection. But it is seldom if ever necessary now to treat the stump as advised by Porro, and performance of the operation as described by him is exceedingly rare.

D. *Extra-peritoneal Cæsarean Section*

Several methods have been devised to approach the lower segment outside the peritoneal cavity, in order to avoid the risk of peritonitis in cases of labour which are frankly septic. The best is Latzko's operation. This is much more difficult than the ordinary operation and should not be done as a routine measure, but if it is ever necessary to operate after many hours of labour, during which attempts have been made to deliver, Latzko's operation is the method of choice.

Published results by Küstner and Bumm (Berlin) show four maternal deaths in a series of 226 operations. and, in addition, Küstner injured the bladder in 7 per cent of his patients, and also had trouble from ureteral fistulæ, hæmorrhage into the broad ligament, and thrombosis. A recent paper by Fleischer and Küstner (*Surg., Gyn. and Obst.*, LXI, Nov., 1935) recommends Latzko's operation for definitely infected cases, and quotes his series of 19 in which there were no deaths, and only four patients who had serious post-partum complications. They remark upon the small amount of hæmorrhage and shock.

Technique. (Quoted by De Lee—*Principles and Practice of Obstetrics.*) Briefly the technique is as follows: The patient is in the Trendelenburg position, and 150 cc. of saline have been injected into the bladder. The catheter is left *in situ* and clamped. The incision is sub-umbilical, and about an inch to the left of the middle line. The knife is carefully carried down to the peritoneum, which must on no account be opened or pricked. In the lower part of the wound the peritoneal fold is sought for and pushed up from the lower segment and bladder. The bladder is recognised by reason of its contained saline,

and then emptied by unclamping the catheter, which is still left in position. The bladder is then carefully peeled off the uterus by pushing it downwards and to the right, while the utero-vesical peritoneal fold is also pushed to its upper limit, off the lower segment. If the woman has been in labour for some time, the lower segment has been pulled up, and a fair area of it is available. *Some care and time is necessary for this* dissection, and all vessels must be tied lest a hæmatoma should form in the space of Retzius. Loose blood is the chief cause of abscess formation later. When the maximum length of the lower segment has been exposed, the lateral areas are thickly padded by swabs to absorb blood (there will be little liquor amnii since the membranes will have been ruptured for some hours in a patient for whom this operation has been selected). A longitudinal incision in the lower segment is made by first making a small hole with a knife at its upper extremity and then completing it with blunt-pointed scissors. The wall will be very thin at this stage of labour. The table is then returned to the horizontal position and the head extracted as described in the previous section. Take care to deliver the child very slowly. When the head has been extracted, take time in sponging the eyes and mouth. The child will certainly be shocked and in poor condition before the operation is begun, therefore do not add to the shock by rapid delivery. Deliver each shoulder slowly and tenderly, and then slowly withdraw the body, quickly clamp the cord, and immediately wrap the child in a warmed blanket and instruct the nurse to place it on an inclined surface with the head down. *Apart from an injection of coramine and a gentle jet* of oxygen and carbon dioxide (7 per cent) playing over the mouth and nose, no other treatment should be administered. On no account should the child be made a victim of artificial respiration.

The wound in the uterus should be sewn up as previously described, and the bladder and peritoneal pouch brought back into position. Any bleeding point is ligatured, the area is carefully mopped dry, the swabs are removed, and a small rubber drain is inserted for 24 hours. The abdomen is closed in the usual way.

SUMMARY OF INDICATIONS FOR THE VARIOUS METHODS OF CÆSAREAN SECTION

The classic operation should only be undertaken *before labour has* begun, for deliberate cases, for certain cases of placenta prævia, where it may be necessary to operate as quickly as possible, in short, for all emergencies where the patient must spend the minimum time on the table. It should also be the operation *of choice for the inexpert and* occasional operator, faced with an emergency, and for all cases where

old adhesions or obstructing fibroids would render the approach to the lower segment difficult.

The lower segment operation has become elective in nearly all clinics abroad and in Scotland, but it has not yet become widely adopted in London. It is specially suitable after labour has begun, i.e. for all trial labours, and in all cases of suspected infection. If, however, for any special reason abdominal delivery must be carried out where infection is certain, perhaps the safest method is the extra-peritoneal method of Latzko. It is, however, difficult, long, and has its own special risks, and it can only be justified by some special importance attached to a child, which, despite efforts at delivery, is still in good condition. Truly, a very rare combination of circumstances!

As a competitor with Latzko's operation, that of Porro would be the winner. It is easier, quicker, and more certain to eradicate the source of infection. Its opponents claim that the peritoneal cavity is opened, and therefore the woman is put to a greater risk of fatal infection. But is it yet certain that the pelvic cellular tissue is more resistant to a rapidly permeating infection than the peritoneum? The writer's experience is that the cellular tissue of the space of Retzius and the base of the broad ligament is more vulnerable than the peritoneum, and of the two operations, Latzko's and Porro's, he feels that the latter is the safer.

The variations of the Cæsarean technique all have for their object the extension of the abdominal delivery to save a child which is still alive, without risking the mother's life by sepsis. Before, or early in, uncontaminated labour there is no problem. But after the membranes have been ruptured many hours, if the child is still alive, there is a problem indeed! We feel that the child, in these circumstances, is never so well as it seems by auscultation, and that, as a rule, Cæsarean delivery at great risk to the mother will yield a child, which, if not born dead, will, after a few gasps, sink into death. It has further to be remembered that success by these desperate operations can only be achieved by expert professional operators who are not often available. *The general practitioner operator, who is usually the one to be faced with these emergencies, cannot be expected to succeed, and he should not attempt them.* What is gained by the delivery of a dead baby from a mother who, even if she survives, will have a stormy, infected convalescence, with the great risk of rupture of the scar in a future pregnancy because of imperfect and infected uterine suture? For these unfortunate women craniotomy is the safer procedure. A little time more and the child will be dead. No prejudices are therefore offended, and the mother will live to have more children.

PART XXI

CARDIO-VASCULAR SURGERY

by

A. J. COKKINIS

CARDIO-VASCULAR SURGERY

Introduction and Historical Review

Cardio-vascular surgery embraces two very different entities. One is the *surgery of the blood-vessels,* which dates its birth from the very dawn of history, deals with such common conditions as arterial and venous wounds, varicose veins, phlebitis, arterial occlusions, etc., and mostly concerns itself with easily accessible and " safe " regions. The other is the *surgery of the heart,* the infant of the surgical art, no older than the present generation, and concerned with the most vital and least accessible of human organs, but already a field of great achievement, and of even greater promise.

Probably the earliest of all surgical procedures was the arrest of bleeding from a wounded vessel by pressure. The ancient Hindus, the great surgeons of antiquity, were familiar with every method of controlling hæmorrhage except the ligature, while blood-letting undoubtedly had its birth in prehistoric times. The first golden age of vascular surgery, however, came in the second century A.D., almost entirely from the work of Greek surgeons. In this century *Heliodorus* first described ligature and torsion of blood-vessels, and *Antyllus* founded the operative treatment of aneurysms with the extremely rational procedure which still bears his name (see page 4062). Also in the second century *Galen* proved that the arteries contain blood, and that a ligated artery pulsates proximal to the ligature, but not distal to it. During the Byzantine period an important contribution was made by *Aetius* in the sixth century, to whom is due the first description of proximal ligature for aneurysm.

After the hiatus of the Dark Ages, vascular surgery shared in the awakening of medical knowledge at the Renaissance. Late in the thirteenth and early in the fourteenth centuries important additions were made by three mediæval surgeons: *Saliceto,* who showed how to diagnose an arterial wound by the spurting of blood, and *Lanfranc* and *Henri de Mondeville,* who arrested hæmorrhage by digital pressure, ligature, and styptics, and were familiar with torsion and acupressure. For some centuries after this it was fashionable to treat wounds and arrest hæmorrhage with boiling oil or cauterisation. Great credit is

CHAPTER I

Surgery of the Heart

SURGICAL ANATOMY AND PHYSIOLOGY OF THE HEART AND PERICARDIUM

Until quite recently the heart was the only important organ the anatomy and physiology of which was not of material concern to the surgeon. This is no longer the case. The heart is now coming into the province of surgery to an extent undreamed of twenty years ago, and the surgeon who aspires to operate upon it must acquire an accurate knowledge of its anatomy and physiology. The importance of its exact position and surface relations, and of the bearing these have on the problems of surgical approach, is obvious. No less essential is a knowledge of its pericardial and other relations, of its blood supply, and of its intrinsic and extrinsic neuro-muscular mechanisms.

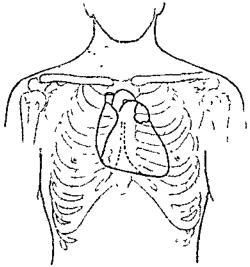
POSITION AND RELATIONS

The heart, enclosed in the pericardium, lies obliquely in the widest part of the middle mediastinum, the space between the two pleural sacs, which is bounded below by the diaphragm and above by an imaginary plane passing from the lower border of the fourth dorsal vertebra to the lower border of the manubrium sterni. *Posteriorly*, the pericardium is separated from the middle four dorsal vertebræ by the contents of the posterior mediastinum, the œsophagus being an immediate contact relation and intervening between it and the descending aorta and thoracic duct. *Laterally*, the pericardium is in close contact with the mediastinal pleura on both sides, the phrenic nerves running down between them a little in front of the pulmonary roots.

varies with the size and build of the patient, and with the presence or absence of bulging of the pericardium or heart; under average conditions the apex of the triangle is at the level of the fourth costo-sternal junction, its base is at the sterno-xiphoid junction, its right margin runs down almost vertically a little to the right of the mid-line, while its left margin slopes down and to the left to meet the base on the sixth left costal cartilage, at a variable distance from the sternum (usually one to two inches). The triangle is thus almost entirely to the left of the mid-line.

The actual topography or *surface marking* of the heart is made clear in fig. 2166, without the need of detailed description. About two-thirds of the organ lie in the left half of the thorax, and one-third in the right half. The surface relations of the heart chambers are roughly as follows: behind the sternal ends of the right

Fig 2166.—Surface relations of heart and pericardium.



costal cartilages is the right auricle, with a little of the right ventricle; behind the sternum is the right ventricle, with the roots of the aorta and pulmonary artery; and behind the left cartilages are the left ventricle and auricle.

Exterior of Heart (figs. 2167 and 2168).

The heart is conical and lies free in the pericardial sac except at its base, where it is fixed by the great vessels which enter and leave it. The *base*, or posterior surface (fig. 2167), looks backwards, upwards, and to the right, and is made by the quadrilateral left auricle (receiving the right and left pulmonary veins), assisted by the posterior surface of the right auricle (receiving the superior and inferior venæ cavæ). The auricles are prolonged forwards into auricular appendices, and between them form a crescent which embraces the roots of the aorta and pulmonary artery; an interauricular groove separates the bodies of the two auricles posteriorly. The *apex* of the heart is directed downwards, forwards, and to the left, and is made entirely by the left ventricle.

The *anterior surface* (fig. 2168) is convex and looks upwards as well as forwards. The greater part of it is made by the right ventricle, but to the right of this can be seen the anterior part of the right auricle, with its appendix, the right auriculo-ventricular groove intervening. To the left of the right ventricle is a narrow area

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Anteriorly, the heart and pericardium are very largely overlapped by the thin front margins of the lungs and pleuræ, which separate them from the lower three-quarters of the body of the sternum, and from the sternal ends of the costal cartilages attached to it (3, 4, 5 and 6). There is, however, an extremely important *triangular area*, opposite the cardiac notch on the front margin of the left lung, where the pericardium is uncovered by the pleura, and where it is immediately related to the left half of the sternum, below the fourth left costal cartilage, and also to the sternal ends of the fifth and sixth left cartilages (fig. 2166). This triangular area constitutes the so-called "*triangle of safety*," and indicates the best approach for exposure and needling or drainage of the pericardial sac. Its size

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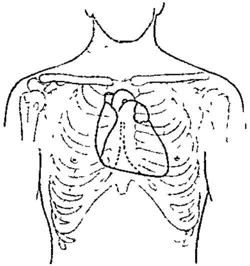

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of left ventricle, forming the thick and rounded left border of the heart, with the anterior interventricular groove intervening. The upper end of this groove is hidden by the left auricular appendix, which projects round from behind. Between the two auricular appendices can be seen the roots of the pulmonary artery and aorta, the former lying to the right and in front of the latter at their commencement.

The *inferior surface* (fig. 2167) is flat and lies on the central tendon of the diaphragm. It is formed mostly by the left ventricle and completed by the right ventricle, with the inferior (or posterior) interventricular groove separating them.

Internal Mammary Artery (fig. 2169).

The exact position of this vessel is of importance, both in the operative approach to the heart and pericardium, and in the diagnosis of precordial wounds.

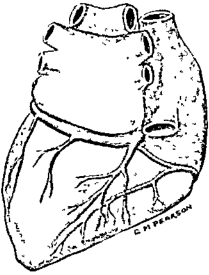

Fig 2167 —POSTERIOR AND INFERIOR ASPECTS OF HEART

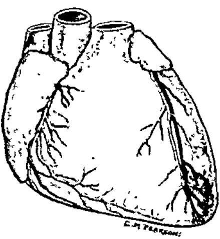

Fig. 2168.—ANTERIOR ASPECT OF HEART.

Arising from the first part of the subclavian, it passes down behind the inner end of the clavicle, and behind the inner portion of all the costal cartilages down to the sixth Accompanied by its venæ comites it lies a quarter to three-quarters of an inch from the edge of the sternum. In front of it are the costal cartilages and intercostal muscles, with the anterior ends of the upper six intercostal nerves. Behind it is the pleura and triangularis sterni muscle; below the level of the fourth costal cartilage the left artery has the pericardium as a posterior relation (in the region of the " triangle of safety "). Reaching the sixth intercostal space, the artery divides into its superior epigastric and musculo-phrenic branches.

The Coronary Vessels (figs. 2170 and 2171).

A knowledge of the anatomy and physiology of the coronary circulation is essential in practically every form of surgical intervention upon the heart. Thus, a main vessel may be included in the suture of a heart wound, with disastrous results, or such a vessel may be pricked in needling for pericarditis, with the production of an intrapericardial hæmorrhage and a fatal acute compression

(tamponade) of the heart. Similarly, a coronary vessel may be torn during the operation of freeing the heart in adherent pericarditis. The physiology of the coronary circulation is particularly important in the very recent surgical procedures

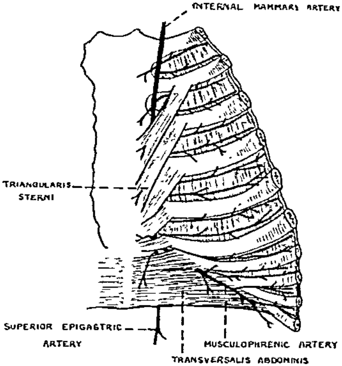

Fig. 2169.—INTERNAL MAMMARY ARTERY.

directed to the relief of angina pectoris, organic coronary disease, and other vascular lesions of the heart.

The *coronary arteries* (fig. 2170) are two in number, right and left, and arise from the sinuses of Valsalva at the very commencement of the ascending aorta.

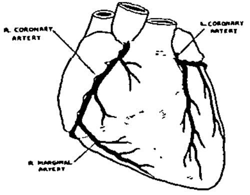

Fig. 2170.—THE CORONARY ARTERIES.

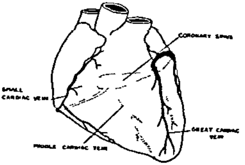

Fig. 2171.—THE CARDIAC VEINS.

They lie on the surface of the heart, embedded in a variable amount of fat. The *right coronary* runs forward between the right auricular appendix and the root of the pulmonary artery, and then down in the right auriculo-ventricular groove, on the anterior surface of the heart. Reaching the inferior surface, the artery gives off a *right marginal branch*, which runs along the lower margin of the heart, towards the apex, and then divides into its two terminal branches: of these, the

facilitates movement, at the same time deprives the greater part of the heart from contact with its environment, and thus from acquiring a collateral source of vascular supply. Normally, the only continuity is by means of the scanty fat, nerves and lymphatics on the walls of the great vessels which enter or leave the heart base. That even this very poor scaffold for an extra-cardiac anastomosis is capable of adequate development is shown by the occasional survival of cases of occlusion of both coronary arteries, but the closure has to be extremely slow for this to happen. In the vast majority death occurs long before a functioning anastomosis can develop. The provision of an abundant collateral vascular bed by surgical operation is one of the most brilliant achievements of surgical research, and will be dealt with in a subsequent part of this section.

The *internal anastomoses* of the coronary circulation have been thoroughly investigated by Leriche and Fontaine, and prove to be functionally efficient up to a point. Ligature of a coronary trunk always causes death from fibrillation, but ligature of a main branch below the first collateral is followed by recovery with a small infarct or a patch of fibrosis in the ventricular wall. These experimental results have been confirmed by radiological studies of opaque injections into the coronary arteries, and by electrocardiographic studies, and the entire research shows conclusively that the internal anastomoses can revascularise an ischæmic territory, provided the occlusion does not involve one of the main coronary vessels.

INNERVATION OF THE HEART

Intrinsic Mechanism. The nerves entering the heart are branches of the right and left *coronary plexuses*, which accompany the coronary arteries, and supply the corresponding heart chambers. Small ganglia are present in the coronary plexuses, in the nerves which supply the auricular walls, and in those which supply the ventricular walls in the immediate vicinity of the auriculo-ventricular grooves.

The coronary plexuses are derived from the *cardiac plexus*, which has superficial and deep portions (fig. 2172). The *superficial cardiac plexus* lies below the concavity of the aortic arch, and receives the superior cardiac branch from the *left* superior cervical sympathetic ganglion, and the inferior cardiac branch of the *left* vagus ; this cardiac plexus is prolonged into the *right* coronary plexus. The *deep cardiac plexus* is found on the trachea behind the aortic arch, and receives the middle and lower cardiac branches of the *left* sympathetic, and the superior cardiac branches of the *left* vagus, as well as all the cardiac branches of the *right* sympathetic and vagus. The deep plexus is continued into the *left* coronary plexus, and assists the superficial plexus in making the *right* coronary plexus.

The above description must be taken as an average arrangement, since there are considerable variations.

The *propagation* and *conduction* of the *heart's contraction* is now known to be the function of a special tract of heart muscle (fig. 2173) which starts at the *sino-auricular node*, a small thickening in the wall of the right auricle just below the entrance of the superior vena cava. This node is regarded as the pace-maker in which the heart's beat originates. From it rather indefinite muscular fibres can be traced to a well-defined *auriculo-ventricular node* (of Tawara), situated in the wall of the right auricle a little below the mouth of the coronary sinus. The node of Tawara forms the starting point of the *auriculo-ventricular bundle* of His,

transverse branch runs to the left in the left auriculo-ventricular groove to anastomose with the transverse branch of the left coronary, while the *descending branch* passes forward in the inferior interventricular groove to the apex of the heart, where it anastomoses with the descending branch of the left coronary.

The *left coronary artery* passes to the left behind the root of the pulmonary artery and appears on the surface by coming forwards between this artery and the left auricular appendix. Here it immediately divides into a *transverse branch* which runs back in the left auriculo-ventricular groove to anastomose with the same branch of the right coronary, and a *descending branch* which passes down in the anterior interventricular groove to the apex, where it anastomoses with the descending branch of the right coronary. From the transverse branch is given off the *left marginal artery*, which runs along the rounded left border of the heart.

The *cardiac veins*, in the main, accompany the coronary arteries, but their arrangement is somewhat different (fig. 2171). Associated with the left coronary artery is the left or *great cardiac vein*; this starts at the apex of the heart, and runs up the anterior interventricular groove, to open into the left extremity of the *coronary sinus*. This wide sinus is about an inch long, lies in the posterior part of the left auriculo-ventricular groove, and opens into the right auricle. In addition to the great cardiac vein, the coronary sinus receives the *middle cardiac vein*, which runs back in the inferior interventricular sulcus, accompanying the descending branch of the right coronary artery, and the right, or *small cardiac vein*, which lies in the right auriculo-ventricular groove with the trunk of the right coronary artery. The marginal arteries are also accompanied by corresponding veins.

PHYSIOLOGY OF THE CORONARY CIRCULATION

The coronary circulation is adapted to the heart's needs by its *vasomotor control*. Unfortunately, there appears to be radical disagreement as to the nature of this control. Until recently Anrep's conclusion that the coronary vasomotor nerves functioned in an opposite manner to that of other vascular nerves was generally accepted. Working on dogs in 1926, he showed that stimulation of the vagus produced vasoconstriction, and that sympathetic stimulation caused vasodilatation of the coronary arteries. On the other hand, Leriche and Fontaine in 1932, also working on dogs, came to the opposite conclusion, viz. that the vasomotor control of the coronary arteries is precisely similar to that of cutaneous and splanchnic vessels; in other words, that the sympathetic is the coronary vasoconstrictor. These seemingly irreconcilable conclusions have been bridged to some extent by the more recent perfusion experiments on the revived human heart reported by Kountz, Pearson and Koenig in 1934; they show that under normal conditions stimulation of the vagus increases the coronary flow. while sympathetic stimulation reduces it, but that in the presence of dissociation of auricular and ventricular contraction the reverse occurs. Although we may conclude that the sympathetic is probably vasodilator to the coronary arteries, these experiments show that *the heart's rate and muscular activity play a more important part in the regulation of the coronary blood-flow* than does the size of the coronary vessels.

Another important matter recently investigated is the *external anastomosis* of the coronary arteries, and the possibility of providing a *collateral blood supply* to the heart in the event of coronary occlusion. The serous pericardial sac, which

facilitates movement, at the same time deprives the greater part of the heart *from contact with its environment, and thus from acquiring a collateral* source of vascular supply. Normally, the only continuity is by means of the scanty fat, nerves and lymphatics on the walls of the great vessels which enter or leave the heart base. That even this very poor scaffold for an extra-cardiac anastomosis is capable of adequate development is shown *by the occasional survival of cases* of occlusion of both coronary arteries, but the closure has to be extremely slow for this to happen. In the vast majority death occurs long before a functioning anastomosis can develop. The provision of an abundant collateral vascular bed by surgical operation is one of the most brilliant achievements of surgical research, and will be dealt with in a subsequent part of this section.

The *internal anastomoses* of the coronary circulation have been thoroughly investigated by Leriche and Fontaine, and prove to be functionally efficient up to a point. Ligature of a coronary trunk always causes death from fibrillation, but ligature of a main branch below the first collateral is followed by recovery with a small infarct or a patch of fibrosis in the ventricular wall. These experimental results have been confirmed by radiological studies of opaque injections into the coronary arteries, and by electrocardiographic studies, and the entire research shows conclusively that the internal anastomoses can revascularise an ischæmic territory, provided the occlusion does not involve one of the main coronary vessels.

INNERVATION OF THE HEART

Intrinsic Mechanism. The nerves entering the heart are branches of the right and left *coronary plexuses*, which accompany the coronary arteries, and supply the corresponding heart chambers. Small ganglia are present in the coronary plexuses, in the nerves which supply the auricular walls, and in those which supply the ventricular walls in the immediate vicinity of the auriculo-ventricular grooves.

The coronary plexuses are derived from the *cardiac plexus*, which has superficial and deep portions (fig. 2172). The *superficial cardiac plexus* lies below the concavity of the aortic arch, and receives the superior cardiac branch from the *left* superior cervical sympathetic ganglion, and the inferior cardiac branch of the *left* vagus; this cardiac plexus is prolonged into the *right* coronary plexus. The *deep cardiac plexus* is found on the trachea behind the aortic arch, and receives the middle and lower cardiac branches of the *left* sympathetic, and the superior cardiac branches of the *left* vagus, as well as all the cardiac branches of the *right* sympathetic and vagus. The deep plexus is continued into the *left* coronary plexus, and assists the superficial plexus in making the *right* coronary plexus.

The above description must be taken as an average arrangement, since *there are considerable variations.*

The *propagation* and *conduction* of the *heart's contraction* is now known to be the function of a special tract of heart muscle (fig. 2173) which starts at the *sino-auricular node*, a small thickening in the wall of the right auricle just below the entrance of the superior vena cava. This node is regarded as the pace-maker in which the heart's beat originates. From it rather indefinite muscular fibres can be traced to a well-defined *auriculo-ventricular node* (of Tawara), situated in the wall of the right auricle a little below the mouth of the coronary sinus. The node of Tawara forms the starting point of the *auriculo-ventricular bundle* of His,

by which the contraction wave is conducted from the auricles to the ventricles. This bundle runs forward just below the thin (membranous) part of the interventricular septum, and shortly divides into right and left fasciculi, which enter

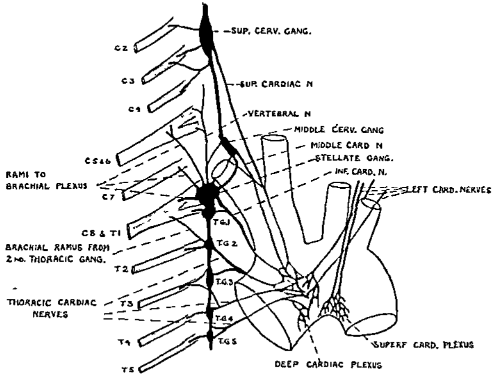

Fig 2172.—THE CARDIAC PLEXUS AND ITS CONNECTIONS.

the septal wall of the corresponding ventricle, and blend with the sub-endocardial muscle-fibres of Purkinje. The whole of this conducting or Hissian system is of vital importance, and it must be carefully avoided in all operative procedures on

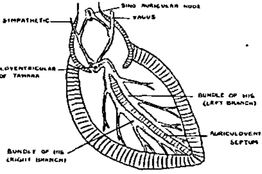

Fig 2173.—THE CONDUCTING MECHANISM OF THE HEART.

the heart. Disorders of this system are often caused by coronary occlusion, and manifest themselves in various disturbances of the cardiac rhythm.

Extrinsic Mechanism (fig. 2172). The heart muscle and the coronary vessels are controlled by *efferent* or *motor* nerves which reach the cardiac and coronary plexuses from the sympathetic and from the vagus. The more conspicuous *cardiac branches of the sympathetic* come from the superior, middle and inferior

cervical ganglia, in the form of three distinct nerves, the superior, middle and inferior cardiac. These nerves consist of post-ganglionic neurones, and since the cervical sympathetic ganglia have *no central connections, except through the stellate* ganglia, the pre-ganglionic motor neurones must come from the upper five or six thoracic white rami and reach the cervical sympathetic chain via the thoracic chain and the stellate ganglia.

Recent work (1927–1933) by White and others, however, has shown conclusively that these cervical cardiac nerves are not the only sympathetic nerves which reach the heart, but that there is a second and equally important group of post-ganglionic fibres which supplies the cardiac plexus, and which comes from the upper four or five thoracic sympathetic ganglia. This discovery is of the utmost significance in the surgical treatment of angina pectoris, and will be further alluded to.

In addition to motor or efferent fibres, the cardiac sympathetic nerves also carry *sensory* or *afferent* fibres, which start as typical sensory nerve-endings in the pericardium, epicardium and heart muscle, and also in the adventitia of the aorta and coronary vessels. It should be noted, however, that there are no sensory paths above the middle cervical ganglion, and that therefore the superior cervical ganglion and its superior cardiac branch are purely motor.

The cardiac branches of the *vagus* are two or three in number. Those on the right side arise from the nerve itself, but at least one of the left cardiac branches comes from the left recurrent laryngeal as it winds round the arch of the aorta. In some animals, and sometimes in man, the *afferent* fibres of the vagus form a separate nerve—the *cardiac depressor* of Cyon and Ludwig, but very often the afferent depressor neurones run in the same cardiac branches as the efferent or motor fibres.

FUNCTION OF THE CARDIAC NERVES

The *vagus* is the *inhibiting* nerve to the heart. By its afferent or depressor fibres it can produce a generalised reflex vasodilatation with a fall of blood-pressure. Its action on the coronary flow cannot be considered as definitely settled. On the one hand, there is evidence that it constricts the coronary arteries, but, on the other hand, it would appear that stimulation of the vagus increases the coronary blood-flow. It is probable that this last effect is controlled by the rate and muscular activity of the heart, rather than by the size of the coronary vessels.

The *sympathetic* is the cardiac *accelerator*; it is probably vasodilator to the coronary vessels; and it is also the *sensory* nerve of the heart.

There appear to be several sensory mechanisms in the regulation of cardiac activity. Leriche and Fontaine demonstrated the presence of an automatic mechanism, by which sensory stimulation of the endocardium and pericardium evokes depressor effects, while stimulation of the aortic region produces pressor effects. The *pain sensibility* of the heart, the aorta, and the coronary vessels is intense, and seems to depend entirely on the sympathetic. According to Leriche and Fontaine the greater part of this pain sensibility can be abolished by removal of the left stellate ganglion, while a bilateral stellectomy completely removes cardiac sensations of pain. On the other hand, White in 1935 stated that bilateral stellectomy results in a partial reduction of cardiac sensibility, and that complete abolition of sensation can only be obtained by resection of the upper

four thoracic ganglia. White's assertion is supported by the anatomical connections of the cardiac plexus (see page 3943), and is of obvious importance in its bearing on the surgical treatment of angina.

Apart from the local or sympathetic sensory mechanism, cardiac pain can also be of the *referred* type, being felt in the skin over the precordial region and the inner surface of the arm. This pain can be abolished by local anæsthesia of the skin areas, but is only of secondary importance in painful lesions of coronary origin.

Another nerve structure which has a definite influence on the heart is the *carotid sinus plexus*, situated round the bifurcation of the common carotid, and receiving afferent fibres from the vagus and efferent ones from the superior cervical sympathetic ganglion. Heymans and others (quoted by White) have shown in 1933 that this small plexus is a highly specialised centre which can affect the heart rate, blood-pressure and respiration. Resection of this plexus has been known to cure attacks of recurrent syncope.

PERICARDIUM AND MECHANISM OF HEART TAMPONADE

The pericardium is a triple-layered sac which surrounds the heart somewhat loosely. The outer layer, or *fibrous pericardium*, is composed of very dense fibrous tissue and is funnel shaped ; its upper narrow end is prolonged from the base of the heart on to the great vessels, while its lower wide end is open and is firmly attached by its rim to the central tendon of the diaphragm, which thus comes to form the actual floor of the pericardial chamber. The extent to which the fibrous pericardium ensheaths the great vessels is as follows : the aorta as far as the origin of the innominate, the pulmonary artery to its bifurcation, and the superior vena cava as far as the entrance of the azygos major vein ; the inferior vena cava in its short thoracic part is entirely intrapericardial, but the pulmonary veins pierce the pericardium immediately before they enter the left auricle. The external relations and surface markings of the pericardium have been considered already (see page 3936).

The inner two layers form a typical closed serous sac—the *serous pericardium*. The outer or *parietal layer* is the thicker of the two, and is closely adherent to the fibrous pericardium and the upper surface of the tendon of the diaphragm, both of which it lines. The inner *visceral layer*, or *epicardium*, is very thin and closely invests the heart and the intrapericardial part of the great vessels. It is intimately connected with the cardiac muscle, except along the auriculo-ventricular and interventricular grooves, where the coronary vessels and a variable quantity of fat intervene. The serous pericardium normally contains about 25 cc. of clear fluid.

The parietal and visceral layers of the serous pericardium meet on the great vessels, at the limits of their investment by the fibrous pericardium. Thus are formed lines of reflection of the serous pericardium, which are known as *mesocardia*, and of which there are two—the arterial and the venous. The *arterial mesocardium* forms a common sheath for the aorta and pulmonary artery, while the *venous mesocardium* includes the four pulmonary veins and the two venæ cavæ. Between the two mesocardia is a tunnel leading from one side of the serous sac to the other; this is the great *transverse sinus* of the pericardium (fig. 2174), and it has the aorta and pulmonary artery in front and above it, and the auricular part of the heart with the great veins behind and below it. The importance of the transverse sinus will be appreciated when methods of temporary arrest of

the heart's action come up for consideration. There is a second or *oblique* pericardial sinus, which is a recess in the venous mesocardium, but this is of no special surgical significance.

Cardiac tamponade is the name given to compression of the heart by accumulation of fluid in the pericardium. It is the chief morbid factor in cardiac injuries, and until it was thoroughly understood no advance was possible in the treatment of these injuries. Although Morgagni first realised the danger of an increase in intrapericardial pressure in 1761, it was not until Rose fully investigated the question and coined the word " Herz-tamponade " in 1884, that its mechanics were properly appreciated.

The morbidity of tamponade depends on the non-distensibility of the fibrous pericardium, except to a very slow rise of pressure. As blood begins to accumulate in the pericardium, sufficient pressure is rapidly developed to produce obstruction of the veins entering the heart, with the result that there is a fall in the arterial blood-pressure, and a rise in the venous blood-pressure. Further tamponade causes a fall of the pulse-pressure, a rise of the pulse-rate, and certain symptoms of

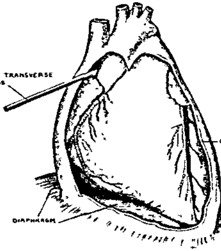

Fig 2174 —THE PERICARDIUM
(*After Buchanan's "Anatomy."*)

which cyanosis is the most prominent. Very soon the resistance of the rigid fibrous pericardium exceeds that of the muscular cardiac wall, and the accumulation of further blood makes room for itself by squeezing the heart and diminishing the capacity of its chambers. Furthermore, when the intrapericardial pressure equals or exceeds the venous pressure, the heart fails to fill, and its output becomes still more seriously endangered.

Such are the mechanics of *acute tamponade.* Owing to the severe embarrassment of the heart, resulting from the diminution of its capacity and of the amount of blood at its disposal, only a moderate quantity of fluid (200–250 cc.) will suffice to cause fatal cardiac compression. The rapidity of tamponade is an important factor, for if the accumulation of fluid is slow enough the fibrous pericardium will distend until the limit of its elasticity is reached. Under such circumstances the condition is a *chronic tamponade,* and more than two litres of fluid may collect before the intrapericardial pressure reaches the venous pressure, and serious cardiac compression begins. It must be understood that chronic tamponade never occurs in connection with heart wounds, although it may be an important factor in pericardial effusion, and in hæmopericardium from a constitutional disorder such as scurvy.

Wounds of the Heart

INTRODUCTION

Unquestionably the best results of cardiac surgery attend the suture of traumatic wounds of the heart. It was with this operation that heart surgery was born forty years ago, and there can be nothing more dramatic in the whole sphere of the science of healing than the saving of a life, otherwise doomed to certain death, by this most recent and brilliant achievement of the surgeon's art.

The *history* of the surgery of cardiac injuries is of considerable interest. Injuries of the heart were thought to be invariably fatal until Wolf in 1642 first described a healed heart wound in a deer killed in the chase. In 1882 Block reported several recoveries after suture of cardiac wounds in rabbits, while in 1895 Del Vecchio showed healed wounds in the hearts of dogs, also after suture. Yet in 1883 the great Billroth stated that " the surgeon who attempted to suture a wound of the heart would lose the respect of his colleagues." In 1895 Cappelen of Christiania was bold enough to suture a wound of the human heart for the first time. The attempt was unsuccessful, and in 1896 Stephen Paget made the following ponderous statement: " The surgery of the heart has reached the limit set by nature to all surgery; no new discovery can overcome the natural difficulties that attend a wound of the heart." Later in the same year Rehn of Frankfurt (September, 1896) first successfully sutured a wound of the human heart! Ten years later Rehn was able to collect 124 cases of heart suture with a 40 per cent recovery. Since that time the cases published and the ratio of recoveries have both risen very considerably. In 1920 Tuffier collected 305 cases with a recovery rate of over 50 per cent, while Ballance analysed 152 cases operated on between 1912 and 1920 (many of them in the Great War) and found that 68·4 per cent recovered. Finally, Cutler reported 28 cases of heart suture between 1920 and 1926, with recovery in no less than 78·6 per cent.

The suture of a wound of the heart must now be regarded as an established surgical operation of very definite life-saving value, and one which every practising surgeon should be prepared and equipped to perform.

MORBID ANATOMY AND CAUSATION

A large heart wound which communicates freely with the exterior, the mediastinum, or the pleura, will prove fatal from hæmorrhage long before surgical aid can be obtained. The cases which can be saved are

those with small wounds, which very soon lose their communication with the exterior by clotting, or by shifting of the tissue planes over the heart owing to changes of posture after the injury, or because the wound of the pericardium is valvular. Such a patient does not die from hæmorrhage, but from the accumulation of blood trapped in the pericardium, and from the *cardiac tamponade* or compression caused thereby. The mechanics of heart tamponade and the factors responsible for its lethal effects have already received sufficient consideration (see page 3945).

Heart wounds of this character are usually inflicted by stabs with various sharp weapons, by bullets, or by shrapnel. The point of entry is mostly to the left of the sternum, in the third, fourth or fifth interspace, and the left ventricle is the part most often injured. The right ventricle is the second most common site of injury, the skin wound being either to the left or to the right of the sternum. The auricles are less frequently involved, but many cases are reported of injuries of one or other of them. Wounds of the posterior aspect or base of the heart are only rarely amenable to surgical treatment. It should be observed that a very small wound of the heart may cause fatal tamponade, and that it may do so without penetrating into a cardiac chamber. Cutler records a fatal tamponade after diagnostic needling of the pericardium, the needle having pricked a coronary vein. Several similar cases have been published.

DIAGNOSIS

Accurate and timely diagnosis of a heart wound is of the utmost importance. Exploratory operations without adequate reason, and delay in the presence of strong evidence of cardiac involvement, are to be equally deprecated. There are three factors which are sufficiently typical to be of real diagnostic value : (1) an external wound, (2) a short free interval following its infliction, and (3) the symptoms and signs of tamponade.

(1) *The External Wound.* A skin wound near the edge of the sternum and between the second and sixth costal cartilages should suggest the possibility of heart injury, particularly if inflicted with gun-shot, or with a weapon sharp enough and long enough to penetrate the necessary distance. The actual position of the skin wound, although of obvious importance, may be deceptive, unless the position of the patient and the trajectory of the missile, or direction of the stab, are either known or can be reconstructed.

Immediately after the wounding there is usually very brisk bleeding, which is of diagnostic importance, especially if it occurs in spurts coinciding with the pulse ; but it should be known that a severed

internal mammary artery may bleed severely enough to resemble a heart injury at first sight. Blood mixed with foam suggests lung injury, but it may also come from the heart, having been churned up in the pericardium.

In rare cases the instrument of trauma, e.g. a dagger, may still be *in situ*, plugging the wound and perhaps preventing hæmorrhage. Such an instrument may oscillate with the heart beat. It should not be disturbed until the patient reaches the operating table, as its premature withdrawal may prove fatal. A famous example of this was supplied by the case of the Empress Elizabeth of Austria, who died in 1898 after the withdrawal of a file from her heart.

(2) *The Free Interval.* This is very short, lasting about ten minutes on the average. Apart from wound pain, the patient may complain of very little. Very soon the external bleeding diminishes or may cease completely. Blood begins to accumulate in the pericardium, and the stage of tamponade is ushered in.

(3) *The Tamponade.* The symptoms of cardiac compression appear, often somewhat abruptly, at a short but variable interval after the injury. The length of this interval, the degree of tamponade, and the rate at which it develops, depend on the presence or absence of an outlet through the pericardial wound; the size and patency of the outlet are the determining factors, and it matters little whether the communication is with the exterior or with a neighbouring body cavity.

The symptoms and signs of heart tamponade are of the greatest importance, as it is on them that the diagnosis of a heart wound mainly depends. At first the patient is restless and frightened, and feels chilly, clammy, and thirsty. Soon the extremities become very cold, a cold sweat covers the body, respiration becomes sighing and irregular, and the colour changes to a rather suggestive combination of extreme pallor and cyanosis. The pulse becomes weaker and weaker, or comes and goes. The peripheral arteries lose their pulse quite early. The arterial blood-pressure sinks rapidly, but the venous pressure rises and the external jugular and other veins may become very prominent. The collapse increases and the patient sinks into unconsciousness.

Examination of the heart reveals that the sounds are indistinct and muffled and become more so every few minutes. The cardiac dullness may increase a little, but this is of questionable diagnostic value. Equally questionable is the wisdom of an X-ray examination; definite information is only likely in cases which are clinically obvious, and the time can be ill afforded.

Briefly, the signs of greatest diagnostic value are: (1) a wound likely to penetrate into the heart, (2) a short symptomless interval, (3) early loss of the peripheral pulse, (4) extreme pallor and cyanosis, (5) prominent veins, and (6) muffled heart sounds.

TREATMENT

Operation at the earliest moment possible is the only hope of saving life, and recent statistics (see page 3946) prove that in cases which survive long enough to reach the operating table this hope is very considerable (more than 70 per cent). The factors which determine success, and therefore influence *prognosis*, are: (1) the time between injury and operation, (2) the size, site and nature of the wound, (3) the presence or absence of other serious visceral injuries, (4) the physical condition and age of the patient, and (5) the skilfulness, coolness, speed, care and judgment of the surgeon.

There can be no question of selection of cases. Every patient who reaches the theatre with the least evidence of cardiac function should be operated upon, as even in the most desperate case the compressed heart may revive immediately the pericardium is opened.

The essential step of the operation is the closure of the heart wound by suture. The closure must be effected in a veritable swirl of blood, without interfering with the circulation through the heart chambers and without obstructing the coronary vessels. Adequate *exposure* is almost as important as the saving of time, for when the pressure is released by incising the pericardium, the heart revives astonishingly, and the patient may bleed to death in a few minutes, and even before the actual wound is found.

The *approach* to the heart is, therefore, of the greatest importance. There are two main routes—the trans-sternal and the parasternal. The *trans-sternal approach* is a long and shock-producing operation, but it ensures the best exposure and gives a reasonable chance of avoiding injury to the pleura. The *parasternal approach*, of which there are several varieties, is a more rapid and much safer procedure, but it does not afford the same exposure of the heart, and is likely to enter the pleura. In spite of these drawbacks, however, the parasternal approach is the one recommended and employed for most cases of heart wounds. Through it the left side of the heart (the most common site of injury) can be reached with ease, and any associated injury of the lung or pleura treated; even injuries of the right heart can be dealt with by employing the wider type of parasternal exposure. We propose, nevertheless, to discuss all established routes of approach, as

even the one least favoured may have special application to a particular case.

In the actual surgical management of a heart wound we may distinguish five steps: (1) the preparation, (2) the anæsthetic, (3) the approach, (4) the cardiac manipulation and suture, and (5) the after-treatment.

1. *The Preparation.*

The patient should be rushed to the theatre on admission and kept warm. All possible time must be saved in preparation of the theatre and patient, sterilisation of instruments, and securing the attendance of a competent surgeon. Intravenous fluid and transfusion are definitely contra-indicated at this stage, as they tend to aggravate the mechanical difficulties under which the heart is labouring.

2. *The Anæsthetic.*

The operation can often be started without anæsthesia, the patient being profoundly unconscious. Advantage should be taken of this stage to insert a tube into the trachea. Soon after the pericardium is opened, however, consciousness may return, and a rapid induction becomes necessary. By far the best and safest anæsthetic is intra-tracheal gas and oxygen. A positive-pressure apparatus should be available, especially when the parasternal route is employed and a large trans-pleural opening may be necessary.

3. *The Approach.*

(*a*) *Trans-sternal Route* (thoraco-abdominal route of Duval Barasty). A mid-line incision is made from the level of the second rib to near the navel (fig. 2175). The linea alba is divided, the ensiform cartilage is excised, and the diaphragmatic attachments are freed as far as necessary. The pleura is pushed away from under the sternum with the finger, a spatula pushed up to protect the soft parts, and the sternum split with a circular saw as far as the second space, where it is cut across transversely. At this stage care must be taken to avoid the internal mammary artery. Section with the circular saw assists careful coaptation later, and so avoids the terrible pain caused by rubbing together of the two halves of the sternum when the division is made with shears. Retractors are now inserted to pull apart the two halves of the sternum, and the two pleuræ are deliberately wiped away to expose the front of the pericardium. The peritoneum, the anterior part of the diaphragm, and the anterior pericardium, are now divided with scissors from below upwards. Finally, the inferior pericardium and left cupola of the dia-

phragm are divided backwards and to the left for a short distance, and thus an extremely full exposure of the heart is obtained. At the end of the operation the two halves of the sternum are wired together, drill holes having been made prior to its division.

(*b*) *Parasternal Route.* There are at least four distinct types of the *left parasternal approach*: the flap or trap-door method, the rib-resection method, the intercostal method, and the Spangaro approach.

(i) *Flap Method.* This is known as Kocher's approach and was in

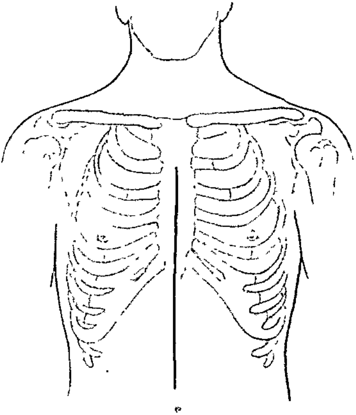

Fig 2175.—Incision for Duval Barasty trans sternal approach

general use till recently. A flap or trap-door is turned out, consisting of the whole thickness of the chest wall, and including the third, fourth, fifth and sixth left cartilages. The cartilages should be lifted off the pleura with great care to avoid injury of the latter. The pleura is either pushed aside or opened, according to the degree of exposure required. At the end the whole-thickness flap is replaced and sutured in layers.

(ii) *Rib Resection* (fig. 2176). This is a modification of the above method, in which various lengths of costal cartilages and ribs are removed.

(iii) *Intercostal Method.* A long major thoracotomy incision is made along the fourth left intercostal space, the pleura divided, and an adequate exposure obtained by wide retraction with rib-spreaders.

(iv) *The Spangaro Method* (fig. 2177). Undoubtedly the best of the parasternal approaches, this is quick, simple, gives a fair exposure, and renders air-tight closure of the thorax easy. In brief it may be termed an *intercosto-chondrotomy*. A long incision (from sternum to anterior axillary line) is made through the intercostal space nearest the wound (usually the 4th space, but in high wounds the 3rd or even the 2nd—

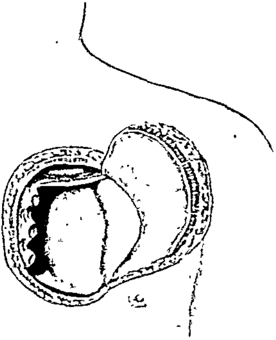

Fig 2176.—PARASTERNAL APPROACH WITH RIB RESECTION.

see fig. 2178). A second incision is made along the sternal edge, making the skin incision T-shaped. The sternal attachment of as many costal cartilages as necessary—at least one, but preferably two above and below the incised space—is separated from the sternum (fig. 2178). The internal mammary artery is ligatured above and below, the pleura divided, and a rib-spreader applied. The lung is packed off and the pericardium identified and incised. Good exposure is obtained only of the left ventricle and auricle. To improve the exposure the adjacent part of the sternum may be removed by the gouge or nibbler, or one cartilage with part of its rib may be resected. At the end of the operation air-tight closure of the thorax can be obtained by tying together the two

ribs which margin the rent in the pleura ; this is much easier and more effective than any attempt to suture the pleura.

(v) *Bilateral Parasternal Approach* (see fig. 2179). This was suggested and employed by Beck as an alternative to the Duval Barasty trans-sternal route, when very free exposure of the heart is desirable (e.g. for wounds of the right side or back of the heart). Flaps are raised to each side of the sternum, the 3rd, 4th, 5th and 6th cartilages are removed on both sides, care being taken not to wound the pleura, and the adjacent parts of the sternum are gouged away. The internal

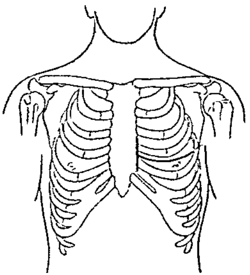

Fig. 2177.—Incision in Spangaro approach. (*Modified.*)

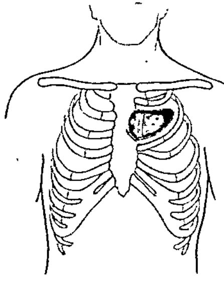

Fig. 2178.—The Spangaro approach. (*After Arthur M. Shipley.*)

mammary vessels are tied above and below and the pleuræ pushed out of the way. This approach gives a beautiful exposure of the whole heart.

Choice of Approach. When there is good reason to believe that the wound is in the *left side of the heart* one of the left parasternal methods should be employed. The Spangaro approach is the best of these, and is particularly indicated when there is an associated injury of the lung. If the surgeon particularly desires to *avoid opening the pleura* he must choose between the Duval Barasty trans-sternal approach, which gives the best exposure but is also the most dangerous method, and the flap method with resection of costal cartilages, which is very much safer but provides a more limited exposure. It would be most reasonable to start with a left parasternal chondrectomy, to improve exposure by removing the adjacent part of the sternum, and then, if it is thought that more room will be needed, to repeat the procedure on the opposite side ; all this must be done *before* the pericardium is opened.

Many wounds of the *right side of the heart* can be approached by a

left parasternal route, but in cases likely to be difficult, and in injuries of the *back of the heart*, the surgeon must choose between the trans-sternal route and Beck's bilateral parasternal approach.

4. *The Heart Suture.*

The exposure of the wounded heart is only one half of the operation. The other and more troublesome half is finding and closing the wound in the midst of hæmorrhage, which, as soon as the pericardium is opened, becomes imminently dangerous. This is where the deliberate and cool surgeon, who can preserve his equanimity at a critical moment, is a great asset.

Whatever method of approach is used, it ends with the exposure of the pericardium. This will be obviously distended and separated from

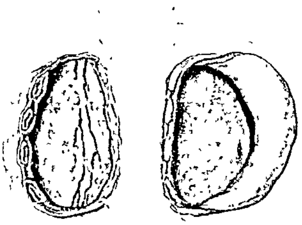

Fig. 2179.—Bilateral parasternal approach. (*After Claude S. Beck.*)

the heart by a lake of blood. The wound in the pericardium is usually found without difficulty, and it must be enlarged quickly and sufficiently to enable the surgeon not only to find and control the cardiac wound, but also to control the beating heart itself. A variable quantity of accumulated blood will be encountered on opening the pericardium; this is mopped away or removed with a sucker. A finger should be passed behind the heart to remove clots. The heart now begins to beat vigorously, and its wound becomes apparent by the ejection through it of big, and sometimes alarming, spurts of blood.

The loss of blood must be immediately controlled. *If the cardiac wound is small* this can be done by applying a finger to it, but the application must be *very gentle*, as the heart muscle is friable and the wound will be made larger if any force is used. The surgeon now inserts

a suture under the finger, this being left untied and used for hæmostasis and traction (fig. 2180). If there is any difficulty in getting to the wound, a *traction suture* should be passed through the thick *apex* of the heart, and with this the assistant can steady the organ, and also pull it or rotate it to bring the wound into a better position for suture (e.g. in wounds of the right ventricle or auricle).

The actual *suture* of the heart should be done with thin black silk or chromic catgut, threaded on small curved round-bodied needles, on a needle-holder. They should all have been previously prepared and threaded, and they must be inserted and tied very gently. Two or three interrupted sutures suffice to close most cardiac wounds which reach the surgeon, but great care is needed to avoid injury to or inclusion of a coronary vessel.

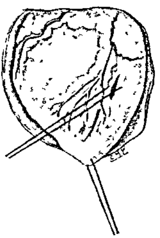
Fig 2180.—Traction and control heart sutures.

With a *large heart wound* the finger is useless for the arrest of hæmorrhage, and it may be necessary to compress the heart base. Recently (December, 1935) Kiser has shown that, while the heart will not tolerate compression of the great arterial trunks (aorta and pulmonary artery), it can survive after compression of the great veins entering it, provided this is not prolonged for more than two minutes. On the human heart this method of temporary arrest is best effected by compressing the venous side of the heart base between the third finger of the left hand, which is passed into the transverse sinus of the pericardium (see page 3944), and the fourth and fifth fingers, which are passed in front of the inferior vena cava; this manœuvre leaves the thumb and index finger free for holding and steadying the heart. One or two control mattress sutures are now passed through the wound and further hæmorrhage is arrested by traction on them, while the final sutures are inserted and tied. Compression of the base must be relaxed after a minute, for a few seconds, in order to allow some blood to reach the aorta and coronary arteries. The mortality of heart wounds which require compression of the base is bound to be high.

At or before the conclusion of the suture an injection of 1 cc. of 1 in 5000 adrenalin may be made into the cardiac muscle if the heart is beating feebly, while cardiac massage should be tried if it actually stops.

After dealing with the heart, the pericardium is cleansed with saline and sutured. When absolute hæmostasis has been obtained the

pericardial suture may be completed, but if there is any doubt the lower corner of the pericardium must be left open for drainage, and a tube inserted down to it (but never into it) for 48 hours. Any associated injury of the lung is now sutured with gently inserted mattress sutures, and the pleura, if opened, is closed in an air-tight manner; in the Spangaro approach this is done by tying the ribs together over the pleural rent. When positive-pressure anæsthesia has been employed collapse of the lung will have been prevented, while if moderate collapse has been encouraged for the purpose of improving exposure the lung should be re-expanded at the end of the operation; otherwise, the air in the pleura must be removed by aspiration after the chest is closed. Finally, the thoracic wall is sutured in layers.

In a recent article, Mayer (*Surg., Gyn. and Obst.*, May 1936, 852) advises against external drainage after operations for heart wounds. Instead, he recommends internal drainage by leaving a wide communication between the pericardium and pleura. If much fluid accumulates in the pleural cavity, it may be removed by aspiration.

5. *After-Treatment.*

Post-operative care is important; quiet, warmth and anti-shock measures are always necessary. One of the most troublesome early complications is delirium due to cerebral anæmia; this is common and may need a good deal of morphia for its effective control. Pleural effusion is almost inevitable if the pleura has been opened, and this will require repeated aspiration. The oxygen tent has proved very valuable in such cases. Occasionally the pleurisy terminates in empyema, which may necessitate drainage.

Surgery of Suppurative Pericarditis

PATHOLOGY

Acute pericarditis is rarely a primary lesion; it is mostly seen as a *complication* of other infective conditions. Perhaps its commonest causes are *pneumonia* and *empyema*, but it may also complicate *rheumatic carditis* with *secondary infection*. Another fairly frequent cause is *pyæmia*, especially when this is a sequel of acute *osteomyelitis*. Rarely, infection may be direct, through external *trauma*. In a somewhat different category is *tuberculous* pericarditis, which may be either primary, or secondary to phthisis or pleurisy.

The *morbid anatomy* is similar to that of suppurative inflammation of any serous sac. The serous pericardium shows the usual changes of acute inflammation, and is filled with a serous exudate which becomes

progressively more purulent. When the accumulation of fluid is rapid the principal morbid factor is *tamponade*, although it must be understood that a larger quantity of fluid will be needed to compress the heart than in cases of wounding, as the accumulation is bound to be much slower, and the fibrous pericardium will give way to some extent. With a more chronic exudation the pericardium will enlarge to the limits of its elasticity, and tamponade will be a late and relatively unimportant feature. In such cases the principal lethal factor is *infection* of the pericardium, heart and other tissues.

DIAGNOSIS

This, of course, belongs to the province of the physician, but from the large number of undiagnosed cases which reach the post-mortem room it would appear to be a difficult matter. Together with the general symptoms of a severe infection, acute cases may show a friction rub, followed by the signs of enlargement of the pericardium (increased dullness, muffled heart sounds, etc.), and perhaps by the clinical features of heart tamponade (see page 3946). An *X-ray examination* is of real service; it shows marked enlargement of the heart shadow in all directions, but particularly in the transverse diameter, while pulsation is barely visible, and may be absent. *Diagnostic puncture* should only be employed when absolutely necessary, as it is definitely dangerous. Several cases are recorded where the needle pricked a coronary vessel or a thin part of the heart wall, causing a fatal tamponade from hæmopericardium.

SURGICAL TREATMENT

The best hope of saving life lies in *drainage* of the pericardium in the most dependent position. In the approach to the pericardium it is best to avoid the diaphragm, and to reach it by a trans-sternal or a trans-chondral route. All drainage operations (pericardiotomy) are based on the triangular area behind the lower and left part of the sternum and the adjacent parts of the fifth and sixth left costal cartilages, where the pericardium is uncovered by the pleura. For a full description of this "triangle of safety" the reader is referred to page 3936, but it should be remembered that owing to the bulging of the distended pericardium the triangular area tends to be somewhat larger than normal.

Trans-sternal pericardiotomy, by trephining the sternum just above the ensiform cartilage, was first suggested by Riolanus as long ago as 1648. It has fallen into disuse because the approach is too cramped

to permit introduction of the finger for the purpose of freeing adhesions.

The *trans-chondral approach* gives an excellent exposure, and can be effected under *local anæsthesia.* A 2-3-inch incision is made along the left edge of the sternum and the 7th costal cartilage, the 6th and 7th cartilages are removed sub-perichondrally, and the internal mammary vessels pushed aside or tied. The pericardium now comes into view. One difficulty of the operation is that the beating apex of the left ventricle always seems very near, and it is impossible to know how thick the pericardium is, and whether it is adherent or not. Another difficulty is that the pericardium tends to fall back out of sight after the fluid has been let out. For these two reasons the pericardium should always be picked up with two traction sutures, the fold thus produced

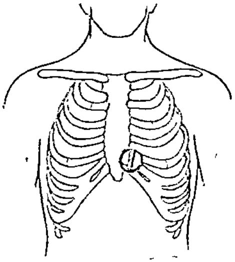

Fig. 2181.—Approach for pericardiotomy. (*After Arthur M. Shipley*)

carefully palpated to estimate its thickness, and the incision made between the sutures. A finger is then inserted and any recent adhesions are gently broken down. After the fluid has escaped, the pericardium is washed out with saline, and a drain applied just to (but not through) the hole in it. Dakin's solution and other irritating fluids should not be used for the irrigation as they are liable to cause pericardial adhesions.

Recently, Shipley has advocated a *combined trans-sternal and trans-chondral approach* (fig. 2181). The sternum is trephined a little to the left and just above the ensiform, the opening enlarged to the left edge of the sternum, and the adjacent parts of the 6th and 7th cartilages cut away. This approach gives a very free exposure.

After-Treatment consists in securing maximum drainage by employing the ventral position for short periods. Pockets of pus can be reached by inserting

a catheter through the wound. Pericardiotomy usually gives great and immediate relief, but the pus discharge is likely to continue for a long period. Pericardial adhesions are a possible sequela and should be watched for.

Some years ago (1930) Beck and Cox drew attention to the cardiac embarrassment which might be caused by the loss of negative pressure following *open pericardial drainage. They showed that after pericardiotomy there is a fall* in arterial pressure, a rise in venous pressure, and a diminished cardiac output. It may be that *closed drainage* will prove the best treatment for pericardial effusion, and that it will be followed by improved results.

Surgery of Chronic Adhesive Pericarditis

INTRODUCTION

No literature of a great surgical achievement could make more fascinating reading than that which describes the advent and elaboration of operative treatment in chronic pericarditis. That the various operative procedures were first conceived and suggested by physicians is a clear indication of the helplessness of our medical colleagues before this merciless disease, which slowly but surely cripples the heart by anchoring it to the chest wall or some other unyielding neighbour, or equally surely shackles and strangles it by a massive pericardial fibrosis. It is to the credit of surgery that it responded to the call of its sister science, and that surgeons appeared with the audacity and skill required to solve unfamiliar problems, and to achieve a measure of success.

Of the numerous contributions which have recently been published on this subject, the most useful and comprehensive is that of Lenormant and Leriche, which was written in 1932, and of which free use has been made in the preparation of this section. Among other excellent articles which have been utilised is one written by Cutler, and another by Shipley, also appearing in 1932. Great credit must also be given to Beck and Griswold, who investigated the morbid changes of this disease in dogs, in whom they produced a constrictive pericarditis by irrigating the pericardium with Dakin's solution.

PATHOLOGY

Pericardial adhesions are a common post-mortem finding, but a large majority of them are of little clinical significance. Those that interest us are the relatively rare ones which cause progressive interference with the heart's action. Such cases of adhesive pericarditis are seen mostly in childhood or adolescence, and the great bulk of them are caused by either *rheumatism* or *tuberculosis*. Among less common

causes are suppurative pericarditis, injury with hæmopericardium, pleuro-pulmonitis, and mediastinitis.

Adhesive changes involving the pericardium may be partial or diffuse. They may be limited to the serosa, or they may spread beyond this to the myocardium, the fibrous pericardium, or the extrapericardial structures. They may scarcely hamper the heart, they may disable it by fixing it to the chest wall or diaphragm, or they may cripple it completely by encasing it with a thick mass of constricting fibrous tissue. It is therefore obvious that several distinct pathological and

Fig 2182.—Adherent pericardium.
(*Museum, Royal College of Surgeons*)

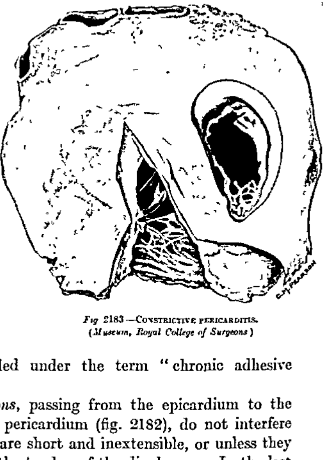

Fig 2183.—Constrictive pericarditis.
(*Museum, Royal College of Surgeons*)

clinical pictures are included under the term "chronic adhesive pericarditis."

Single or *partial adhesions*, passing from the epicardium to the serous lining of the fibrous pericardium (fig. 2182), do not interfere with the heart, unless they are short and inextensible, or unless they anchor the apical region to the tendon of the diaphragm. In the last case serious cardiac trouble may be caused since the heart is dragged on by each respiratory movement.

A more *complete adhesive process* obliterates the serous space and fixes the fibrous pericardium to the heart. As a rule, some part of the pericardial cavity is left unobliterated, especially on the right side of the heart, and may enclose a serous or purulent fluid. Once initiated,

the adhesive fibrosis does not limit itself to the pericardium, but tends to spread beyond it, either to the mediastinal cellular tissue, or to the sub-epicardial heart muscle. Hence, we are able to distinguish two more or less distinct varieties of *diffuse adhesive pericarditis*: (1) the external or centrifugal type, which may be termed *mediastino-pericarditis*, and (2) the internal or centripetal type, which constitutes the *constrictive pericarditis* of English writers, and the *pericardite calleuse* of French writers.

Adhesive mediastino-pericarditis is the classic type, in which adhesions and fibrosis not only obliterate the pericardial space, but also extend beyond the fibrous pericardium, and fix it to the pleura, diaphragm, sternum and ribs, and sometimes even to the spine. It is obvious that such fixation of the heart is bound to interfere with its mobility and contraction, and that it must ultimately lead to progressive cardiac failure and death. This is particularly the case when the heart is anchored to the rigid anterior wall of the chest. Continuous shortening of the anterior mediastinal adhesions exercises progressive traction on the heart, which exhausts itself by pulling against the unyielding parietes. At the same time, the front margins of the lungs, which normally move in to occupy the space created by the systolic retraction of the heart, can do so no longer, since they also share in the adhesive process. There is thus produced a profound interference with cardiac systole, and finally systolic retraction becomes impossible and the heart fails.

Constrictive or *callous pericarditis* is more common and even more serious than the above, although our knowledge of its pathology and clinical significance is more recent. In this, the morbid changes mainly affect the epicardium, and consist briefly of a massive fibrosis immediately surrounding the heart. This becomes immured in a great mass of fibrous tisue (fig. 2183), perhaps a quarter of an inch or more in thickness, which is rigid and pitilessly retractile, and which may become almost cartilaginous in consistency. Sometimes the fibrosis is more marked round the right heart, sometimes round the left. The sclerosis starts in the epicardium and in the intrapericardial adhesions, but later it invades the heart muscle itself, into which it may spread very deeply; calcification is not uncommon in the masses of scar tissue.

The heart is imprisoned in its fibrous armour, the progressive contraction of which literally strangles it. Diastole is the first cardiac function to be interfered with. The thick wall of the left ventricle resists this compression for a time, but the thin-walled auricles feel it very early. Pulmonary stasis results from interference with left

auricular diastole, while stasis in the territories of the superior and inferior venæ cavæ occurs, partly because diastole of the right auricle is impeded, but also because the actual mouths of the cavæ are caught in and compressed by the encasing fibrous mass. Pulmonary venous stasis is thus evidence of constrictive pericarditis of the left heart, while systemic venous stasis shows that the right heart is involved.

The interference with cardiac diastole becomes greater and greater, the venous stasis more and more marked, and progressive heart failure is the inevitable result. It may be accelerated by the myocardial fibrosis, or even by an actual myocardial ischæmia due to compression of the coronary vessels by the pericardial fibrous masses.

Although these two types of adhesive pericarditis produce such very distinct and different morbid changes, in actual fact they frequently coexist in the same patient. Depending on the nature of the combination, and on the degree to which one type predominates over the other, both the pathological and the clinical picture of the disease will obviously show considerable variation.

DIAGNOSIS

It follows from the last paragraph that we may expect two types of clinical syndromes, one produced by adhesions between the pericardium and its surroundings (mediastino-pericarditis) and the other by constricting or callous pericarditis.

Mediastino-pericarditis is associated mainly with parietal symptoms. The apex beat becomes fixed and does not move with changes of position. There may be very marked systolic retraction of the chest wall, both in the precordial region and posteriorly at the vertebral ends of the left 9th, 10th and 11th ribs (Broadbent's sign). The precordial region may also show a diastolic rebound. *Adhesions to the diaphragm* are responsible for the so-called *pulsus paradoxus* of Kussmaul, in which the pulse weakens or disappears on inspiration.

Constrictive pericarditis is characterised by lack of objective heart signs and by the presence of the features of *venous stasis*. The clinical picture is typical and has come to be known as *Pick's syndrome*. The outstanding signs are: (1) *Ascites*, which is copious and which recurs constantly after paracentesis; (2) *hydrothorax*, which is less commonly present; (3) *enlargement of the liver* from passive congestion (Pick's pseudocirrhosis); (4) *œdema* and *cyanosis* of the face and chest wall; and (5) *raised venous pressure* to as much as three or four times the normal, with *prominent jugular* and other veins.

Marked hydrothorax strongly suggests compression of the left

auricle, while ascites and liver enlargement point to constriction of the right heart.

In spite of the characteristic nature of these symptoms and signs, the *diagnosis* is far from simple, and the best clinicians may be deceived. One difficulty is that cases rarely conform to one or other type of chronic pericarditis, but often present confusing and various combinations of the two. Another difficulty is that the absence of parietal signs does not exclude anterior mediastinal adhesions, since it may mean that the myocardium is becoming exhausted. Furthermore, none of the symptoms of Pick's syndrome is pathognomonic of pericarditis, as they may be produced by other causes of cardiac embarrassment. Electrocardiography, although useful in prognosis, does not assist diagnosis.

It is, in fact, the difficulties in diagnosis which constitute the chief stumbling block to the surgical treatment of chronic pericarditis. Fortunately, expert *radiography* is proving of real assistance, and promises to provide us with a reliable means of diagnosis. The outstanding *X-ray signs* of adhesive pericarditis may be summarised as follows: (1) enlargement of the heart shadow in all directions, (2) fixation of the heart in all positions, and (3) loss of normal cardiac movement with respiration. These three signs are seen in both types of adhesive pericarditis. In constrictive pericarditis the following may also occur: (4) loss of the anterior mediastinal space, and (5) complete immobility of the right border of the heart, while its left border may retain some movement. In adhesions of the apical region to the diaphragm two additional signs may be present: (6) pulling up of the diaphragm at systole, and (7) elongation of the heart shadow on inspiration.

SURGICAL TREATMENT

Adhesive pericarditis is a progressive and inevitably fatal disease. It attacks patients in their youth, completely incapacitates them, and kills them usually in a few years. The actual duration of life is determined by the nature of the infection (tubercle having the worst prognosis), by the degree of cardiac fixation and constriction, and by the condition of the myocardium and cardiac valves.

The failure of medical treatment to do more than palliate the symptoms justifies surgical intervention in every case in which diagnosis is established and the patient has a reasonable chance of surviving operation. Experience has shown that there are two kinds of operative procedure which may be expected to rectify or relieve the mechanical obstacles that encompass the heart: (1) *direct* surgical attack on the

pericardium and its adhesions, and (2) *indirect* procedures which ease the heart's work by removing portions of the thoracic wall or by paralysing the diaphragm.

Operation on the parietes was first proposed by a physician, Brauer (1901), who conceived the brilliant idea of removing a part of the anterior thoracic wall, with the object of releasing the heart. Petersen first performed this operation in 1902, and its simplicity and ease rapidly made it an established procedure. Quite soon, however, it became obvious that whilst very successful in some cases it proved a complete failure in others. Until the reason for these failures was understood, they naturally impeded the further progress of pericardial surgery; but we now know that it is only in the absence of constrictive pericarditis, and when the main cause of cardiac embarrassment is fixation of the heart to the chest wall, that this operation of *precordial costo-chondrectomy* is likely to prove really successful.

Paralysis of the left diaphragm, by alcohol injection or avulsion of the phrenic nerve, was introduced by Sauerbruch in 1925, but is only effective in the rare cases of adhesion between the heart and the diaphragm. It is fortunate that this condition is diagnosable by radiography (see page 3965).

Operation on the pericardium was first suggested by another physician, Weill, as long ago as 1895, but the first actual attempt was made by Hallopeau in 1910. In its early form, the operation was performed with the object of breaking down fibrinous adhesions in the sub-acute stage of pericarditis, but this was illogical as the adhesions were almost bound to re-form. Later, this procedure was applied to chronic cases, single or limited organised adhesions being divided after a deliberate exposure and incision of the pericardium. The operation came to be known as *cardiolysis*, and in the right cases produces brilliant results, but its indications are extremely rare, as the adhesive process is usually too extensive to permit of its application.

Faced with these failures, surgeons abandoned direct operations on the pericardium, until in 1920 Rehn of Frankfort introduced *partial resection* of the parietal pericardium. This was done after freeing as many intrapericardial adhesions as possible, and to prevent their recurrence a fat graft was inserted between the heart and fibrous pericardium. Although this operation proved transitory, it led in due course to the modern operation of *complete pericardiectomy*, for constrictive pericarditis, in which the heart is decorticated to the extent of baring the heart muscle. This brave procedure, although admittedly dangerous, has given a reasonable hope of lasting improvement in the

hitherto hopeless cases of callous pericardial fibrosis. Although it was first performed by Schmieden, and has been warmly advocated by Beck, Griswold and Churchill in America, and by Lenormant and Leriche in France, the credit for its inception must again be given to a physician, Volhard.

OPERATIVE TECHNIQUE

1. *Precordial Costo-chondrectomy* (Brauer's operation). The ideal anæsthesia is bilateral intercostal nerve block with local infiltration, but in children this will need to be supplemented with light general anæsthesia. A flap is raised to the left of the sternum, and the 3rd, 4th, 5th and 6th costal cartilages and ribs are resected for about four inches. Subperiosteal removal of the ribs and cartilages is a safe and rapid procedure, but there is danger of regeneration of the ribs, especially in children. Extraperiosteal resection avoids this danger, but it is a more difficult operation and is associated with the risk of injuring the pleura.

2. *Pericardiectomy* (Volhard-Schmieden). One should always start by doing a precordial costo-chondrectomy, as this not only gives access to the pericardium, but also frees the heart from the rigid parietes. For this reason we do not recommend the trans-sternal approach, in spite of the excellent exposure it provides. The costo-chondrectomy is, of course, extraperiosteal, but owing to the massive fibrosis there is little danger of opening the pleura, provided sufficient care is exercised. The object of the pericardiectomy is to free the heart from its constrictive armour by a maximal degree of decortication ; success depends on a wide exposure of the brown, muscular surface of the heart. The procedure is extremely formidable, as there is no natural line of cleavage between the heart muscle and the fibrous mass covering it, and there is a real danger of tearing through into one of the cavities of the heart, especially when dealing with the right ventricle. Some authorities, in fact, recommend that the right ventricle should be left alone unless skiagrams show that the right border of the cardiac shadow is rigid. The danger of decorticating the auricles is too great to justify the attempt.

The decortication starts with an incision through the whole thickness of the callous mass over the left ventricle ; this is made cautiously and in stages, until the brown muscle-fibres are seen. The mass is then peeled off, partly with the fingers, and partly with the scalpel and scissors ; the fibrous covering usually comes off in layers, and very carefully an increasing area of heart muscle is exposed. When it is necessary to decorticate the right ventricle, additional exposure is provided by removing the edges of the sternum, and by excising the costal cartilages

on the right side. This is the bilateral exposure recommended by Beck, and shown in figure 2179. As soon as the fibrous covering is removed sufficiently, the heart recovers its red colour, and may literally jump in its new-found freedom. Rarely, this liberation is followed by acute dilatation of the right ventricle; Schmieden saw one of his patients die on the table from this cause.

Owing to the dangers of decortication, it would be quite reasonable and prudent to content oneself with a precordial costo-chondrectomy in the first instance, and to perform pericardiectomy as a *second-stage* operation if the relief provided by the first is insufficient.

RESULTS

The following valuable statistics are quoted from Lenormant and Leriche, who were able to collect 181 cases of adhesive pericarditis treated by operation. The figures speak for themselves.

1. *Precordial costo-chondrectomy*: 112 cases, with 6 operation deaths (5·3 per cent). Of 65 followed-up cases, 36 died within five years, mostly from rheumatic cardiopathy or tubercle. The remaining 29 show improvement (1 to 8 years after operation), but only about one half of them could be called cures (about 10 per cent of the total).

2. *Cardiolysis* (for partial adhesions): 2 chronic cases—both cured, and 4 sub-acute cases—1 died, 1 cured, 2 untraced.

3. *Phrenicotomy* (for phreno-pericardial adhesion): 4 cases, all cured.

4. *Partial pericardiectomy* (Rehn's operation): 12 cases, with 2 immediate and 4 early deaths, and only 2 certain survivals after a year.

5. *Total pericardiectomy* (for constrictive pericarditis): 47 cases, with 12 operation deaths (mortality of 25·5 per cent), 4 from wounding heart. In 7 cases the operation was not completed, owing to fibrillation, injury of the heart, etc. Of 32 followed-up cases, 8 died within a year (4 from tuberculosis), while the remaining 24 survived (1 to 6 years after operation). Of the survivals, 2 proved failures, while 22 (nearly half the total) were definitely improved.

PRECORDIAL COSTO-CHONDRECTOMY FOR NON-PERICARDIAL CARDIOPATHIES

The success attending the effort to relieve the cardiac effects of adherent pericardium by resecting the precordial parietes naturally led to the application of the same procedure to other cardiopathies, and particularly to those in which there is a marked disproportion between the size of the heart and the size of the thorax. Under these circumstances the operation virtually constitutes a cardiac decompression.

Enormous *cardiac hypertrophy* is the main indication; but the results have not been brilliant, partly owing to the progressively downward course of rheumatic carditis, but also because few physicians will permit surgical intervention until it becomes obvious that medical treatment will no longer delay the inevitable end. Although mainly performed for rheumatic hypertrophy (usually with valvular disease), the operation has also been attempted for pure hypertrophy and for the cardiac enlargement of arterial or renal disease. It has also been tried a few times for the cardiac complications of extreme *thoracic deformity*, e.g. Pott's disease, scoliosis, and severe sternal depressions. Shipley performed the same operation to relieve the pressure of an *expanding aneurysm* of the aortic arch, while Vaquez suggests that it would be a logical method of freeing the heart, when this is compressed by extensive *pleural* or *pulmonary fibrosis*.

The *technique* of the operation has already been described (see page 3965), but it must be insisted that only regional and local anæsthesia is permissible; several deaths have been attributable to general anæsthesia. Owing to the real danger of injuring the pleura or pericardium (more than one death has been due to empyema), the removal of the ribs and cartilages should always be subperiosteal.

The *results* have been summarised by Lenormant, who reported 7 personal cases and analysed 23 cases in all. Of these, 5 died from the anæsthetic or from pleurisy (operation mortality of 22 per cent). Of the 18 survivals, 7 died by the end of the first year, making a 53 per cent mortality within 12 months. The remaining cases show some improvement, while 4 of them were well and at work 2, 3, 7, and 16 years after the operation.

Even this small proportion of cures strongly suggests that with the establishment of clearer indications for surgical treatment, and with better material in the form of patients a little less near the moribund stage, the results of operative *decompression of the heart* will justify its wider application.

Surgery of Valvular Lesions of the Heart

Although the first suggestion that surgery might play a part in the treatment of valvular disease was made by Lauder Brunton as early as 1902, it was not until after the Great War that surgeons seriously turned their attention to this matter. An enormous amount of experimental work was done on animals, and some twelve operations were undertaken on human patients, ten for mitral stenosis, one for aortic

stenosis, and one for alleged pulmonary stenosis. The interest created by this determined surgical attack proved enormous, and, in fact, to many the term " cardiac surgery " came to mean little more than the operative treatment of valvular lesions. In actual fact, however, all this interest and energy ended in complete failure, so far as the results of surgical intervention are concerned, and we have now come to regard such intervention as futile and ill-advised. Indeed, looking into the future, it would be near the truth to state that valvular lesions will probably constitute almost the only cardiopathy in which surgical treatment is contra-indicated.

Despite the fleeting vogue of valvular heart surgery, the experimental and human work done taught us certain lessons, which have proved of value in the surgical treatment of other cardiac lesions. It is, therefore, quite appropriate to review briefly what has been attempted and what has been accomplished.

The experimental research appears to have started with Tuffier and Carrel's attempts at an open approach to the heart valves, with a temporary interruption of the circulation; this was a laboratory feat which could never have the remotest chance of clinical application. Attempts were then made to reach the valves by puncture of the auricular or ventricular wall, and these proved successful in large series of experiments. Cutler and Beck, Allen and Graham, of America, and Wilson in this country, attacked the problems of valve surgery with great enthusiasm, and perfected the technique of approaching the cardiac valves and operating upon them with a minimum of danger to life. Practically all the work was done on the mitral orifice.

The simplest experimental procedure was a blind attempt to divide the mitral valve with a tenotome, introduced through the wall of the left ventricle. This gave a high mortality, a high incidence of failure to find the valve, and often an insignificant breach when the orifice was reached. The ventricular approach was gradually given up, as it was liable to injure the conducting bundle of His, and an approach through the left auricle became fashionable. To obtain a larger breach of the valve Cutler devised a valvulotome, while Allen and Graham invented a cardioscope by which the section could be performed under direct vision. Wilson then combined the valvulotome and cardioscope into one instrument, which he introduced through the left auricular appendix. By these means the mitral valve was divided in a large number of dogs with a very low mortality (Allen operated on 186 dogs with only two operation deaths and without once missing the valve).

Wilson even went to the extent of producing an experimental mitral stenosis on dogs by inserting strips of pericardium across the mitral orifice, and then proceeded to attempt to undo the stenosis by valvulotomy! He reports in the *British Journal of Surgery* (1930) that although normal animals stand valvulotomy well, dogs with experimental stenosis usually succumb owing to the abrupt change over to mitral incompetence.

It is indeed this abrupt change from a mitral stenosis, which the heart has become accustomed to, and for which compensatory mechanisms have been provided, to a mitral incompetence, for which no protective adaptation can exist, that is mainly responsible for the complete failure of operative treatment on human patients. Up to 1929 ten operations were performed for mitral stenosis, seven by Cutler and Beck, and one each by Allen and Graham, Pribram, and Souttar. Souttar dilated the mitral orifice with a finger introduced through the left auricle; his patient survived, but it seems doubtful if serious stenosis was present. Cutler and Beck's first case, in which the valve was divided with a tenotome, also lived for 4½ years, but at death marked stenosis was again present and the left auricle was very dilated. The other eight cases died at operation or within a week, although both valvulotomes and cardioscopes were employed in some of them.

Apart from the mitral valve, only two attempts appear to have been made at valvular operations. Doyen diagnosed a pulmonary stenosis and divided the pulmonary valve with a tenotome introduced through the right ventricle. The patient died soon after, and the lesion proved to be a serious congenital malformation quite unsuitable for surgery. Tuffier (1924) attacked an aortic stenosis by exposing the ascending aorta and invaginating its wall with his little finger, which he states he pushed into the aortic orifice; the fact that this patient was alive eight years later suggests that his aortic stenosis cannot have been severe.

This melancholy recital of absolute failures, with occasional dubious and partial successes, is an eloquent proof that surgeons were ill-advised to interfere with valvular heart lesions. This unwise intervention arose from the hypothesis that mitral regurgitation is a less dangerous lesion than mitral stenosis. If the transition from stenosis to incompetence could be made gradual enough to give the heart and circulation time to accommodate themselves to the altered conditions, there might be some justification for surgery; but the abrupt change from one to the other is bound to be dangerous, and is almost certainly responsible for the fatal outcome of operation in proved cases of mitral stenosis. Even the

protagonists of valve surgery now admit that the sudden change from stenosis to incompetence is likely to prove fatal, but it seems a pity that this procedure was not more thoroughly investigated experimentally *before* it was tried on human subjects. It is true that Wilson did undertake such an investigation and that he showed that it was not the valvulotomy itself, but the sudden change over from stenosis to incompetence, which was dangerous; but his paper was not published until 1930, and this was *after* the short era of human valvulotomy was ended.

SURGERY OF CORONARY CARDIOPATHIES
(Angina Pectoris, Coronary Arteritis and Thrombosis, etc.)

INTRODUCTION

Although Franck in 1899 suggested that surgical treatment might be applied to the relief of angina pectoris, it is strange that no actual attempt to do this was made before 1916, when Jonnesco performed his first cervical sympathectomy for this purpose. The terrible suffering of the victims of coronary disease, the dread of death that it engenders, the frequency with which this dread is justified by subsequent developments, and the helplessness of medical treatment to give adequate relief, should have proved sufficient incentives for the intervention of surgeons, however great the danger incurred, and however difficult the problems involved. That successful surgical treatment is of such recent development cannot, however, be attributed to the absence of surgical initiative; the chief explanation lies in the lack, until quite modern times, of an accurate understanding of the nerves and blood supply of the heart. In fact, our present knowledge of the anatomy and physiology of cardiac innervation, and of the coronary circulation, has been largely obtained through surgical research, and from the results of actual operative intervention on the part of bold and resourceful surgeons

It must be admitted that even to this day there are important physiological points of which we are uncertain, especially on the question of the vasomotor control of the coronary vessels. But the last few years have witnessed a most heartening advance in the application of surgical treatment to cardiopathies of coronary origin, and although several problems still remain to be settled, there is at last real hope that surgery may provide a reasonable chance of permanent relief, and even of cure, in these crippling and hitherto quite hopeless conditions.

PATHOLOGY AND COURSE

Our knowledge of the pathology of *peripheral arterial disease* should prove of value in elucidating the more obscure pathology of *coronary occlusion*. A peripheral artery may be completely occluded by injury, obliterative arteritis, or thrombosis, and the result will be total loss of function and local necrosis (gangrene), unless an efficient collateral circulation is available. Partial occlusion of peripheral arteries may be produced by vasospasm, when it is intermittent, or by proliferative or sclerosing arteritis, when it is continuous and progressive. The result of such partial occlusion is an ischæmia, which is either intermittent or relative, i.e. it shows itself when a special demand is made on the blood supply of the part. This *relative ischæmia* manifests itself most strikingly by the symptom known as *claudication*, a characteristic and severe pain felt in the muscles and produced by muscular effort. With increasing arterial occlusion, the claudication occurs more frequently and with less effort.

An important fact, which has only recently become understood, is that *organic occlusive disease* of the peripheral arteries may be preceded by functional occlusion, or *vasospasm*, and that this vasospasm may be a causal factor in the production of organic occlusion.

There can be no reason why the pathology of *coronary disease* should differ materially from that of disease of other arteries. It is true that the coronary arteries supply blood to the most vital organ of the body, but this is, after all, only a muscle. Different degrees of vascular occlusion must, again, produce effects of different intensity, and there is ample evidence—experimental, clinical and pathological—to show what these effects are. Complete obliteration of a main coronary artery causes death from cardiac failure, often with fibrillation. Complete obliteration of a branch may result in fatal fibrillation, or in ischæmic infarction of part of the heart muscle, with subsequent necrosis and fibrous tissue replacement, or merely in a temporary disturbance of the cardiac rhythm; the determining factors are the size of the obliterated vessel and the efficiency of the collateral blood supply. Transient occlusion (vasospasm) or partial obliteration (e.g. sclerosis) tend to produce an *intermittent* or a *relative ischæmia* of the heart muscle; this is comparable to the relative ischæmia of peripheral vascular disease, and manifests itself in attacks of severe cardiac pain (angina), typically occurring during effort, and perhaps also in disorders of the cardiac rhythm.

The tendency of all arterial disease is to be *progressive*. Peripheral

arteries may pass through a period of intermittent vasospasm, and then develop degenerative or proliferative changes in their walls, leading to progressive *obliteration*, which, perhaps, is finally accelerated by thrombosis. Whether gangrene or other complications result, or not, depends on the efficiency or otherwise of the collateral circulation. Similarly, it is possible that coronary disease starts as a pure vasospasm, and it may be that the so-called true or functional type of *angina pectoris* represents this early or vasospastic stage of the disease. Later, organic changes occur in the arterial walls, and the condition passes on to a *coronary arteritis* or *sclerosis*, while total *occlusion* may be hastened by an attack of *coronary thrombosis*.

The fate of the heart muscle, and incidentally of the patient, will depend on the degree of occlusion, the size of the obliterated vessel or area, and the efficiency of the local collateral anastomosis. Thus the outstanding clinical feature may be attacks of *anginal pain*, associated with less and less effort (a state of claudication); it may lie in the direction of *disturbance of rhythm or rate;* it may be the development of a *cardiac infarct* and scar, which sooner or later yields to produce a cardiac *aneurysm*, or to cause a *spontaneous rupture* of the heart; it may be a less intense but more diffuse *myocardial degeneration* and *fibrosis*, associated with a relative ischæmia and a gradual but progressive failure of the heart: finally, it may be a more or less *sudden cardiac failure*, perhaps after a period of established fibrillation.

The clinical elucidation of these several cardiopathies of coronary origin lies in the province of the physician, and is therefore only of indirect concern to the surgeon. It is also the physician's prerogative to assist the surgeon in the selection of cases, and to a certain extent *to guide him in the choice of the operative procedure likely to prove of* greatest service in any given case. We shall, therefore, at once proceed to consider the objects and available methods of surgical treatment, but before doing so we may perhaps be permitted to express the hope that in the future our medical colleagues will co-operate more closely with us, and will call us to their assistance, both more frequently and also at a stage of the disease when our intervention has a better chance of success.

OBJECTS AND PRINCIPLES OF SURGICAL TREATMENT

Jonnesco published his well-known paper on the surgical treatment of angina pectoris by cervico-dorsal sympathectomy in 1920. Since that date a veritable avalanche of operative procedures has been introduced, supported by hypotheses differing widely and often contradictory. Successes are claimed and failures admitted by all, and the

mass of publications on what has come to be known as *cardiac neurosurgery* has resulted in a state of hopeless confusion, from which one finds great difficulty in extricating the truth. Practically the only factor on which there is general agreement is that surgical attack should be directed to some part of the sympathetic nerve supply of the heart; but since the most recent research leaves us uncertain of the real action of the sympathetic in such an important function as the vasomotor control of the coronary circulation (see page 3940), it is obvious that even this common ground of agreement rests on a shaky foundation.

The first object of surgical intervention was to prevent or relieve the agonising and crippling pain of *angina pectoris*. This was attempted by interrupting the sensory paths along which painful cardiac sensations travel, or by dividing the nervous connections along which vasospastic or pressor impulses reach the heart. Although very worthy in its objects, this treatment was primarily symptomatic, but the claim soon arose that, by abolishing coronary vasospasm, or by improving the coronary circulation in some other way, surgical intervention was indirectly curative, in that it either stopped or slowed down the morbid processes leading to *organic occlusive disease.*

Within the last three years attempts have been made to attack coronary occlusion, and the disabling and usually fatal cardiopathies resulting from it, from an entirely different angle. The first of these attempts was initiated in December 1932, when the operation of *thyroidectomy* was performed for the first time at Boston, U.S.A., with the object of easing the heart's work by lowering the general metabolism, and in the hope that this would influence beneficially the symptoms and course of cardiac disease. In 1933 Blumgart, Levine and Berlin published their paper on the treatment of angina pectoris and congestive heart failure by removal of the normal thyroid gland, while in 1934 Cutler and Schmitker wrote a paper on the same subject. The results of this intelligent if very indirect procedure have in some respects proved astonishing, and at the moment of writing the operation appears to have established itself as a rational and successful treatment in certain selected cases (see page 3979).

Finally, as recently as November 1935, appeared what we have no hesitation in describing as an epoch-making contribution by Claude S. Beck, entitled *The Development of a New Blood Supply to the Heart by Operation.* Coronary occlusion produces its painful and ultimately fatal cardiac ischæmia because the chances of the heart acquiring a collateral circulation by its external anastomoses are negligible (see page 3940). Beck evolved the remarkable conception of

providing the ischæmic heart with an adequate collateral blood supply by a muscle-grafting operation. The operation, and the principles which govern it, will be considered at length a few pages hence, but it should be stated at once that this is the first surgical procedure which actually strikes at the root of coronary cardiopathy, and which gives real hope that the time is near at hand when surgery will be able to do more than merely palliate cardiac symptoms.

OPERATIONS ON THE CARDIAC NERVES

There are three possible ways in which the heart can be influenced by neurosurgical attack: (1) through its vasomotor nerves, (2) through its motor or pressor nerves, and (3) through its sensory nerves. The attempt to influence the *vasomotor* control of the coronary vessels is the most logical of these objects, inasmuch as it aims at elimination of some of the factors responsible for organic coronary disease, as well as the relief of cardiac pain. It has already been stated (see page 3940) that the exact nature of the vasomotor control of the coronary circulation is not yet settled; nevertheless, it appears to be certain that removal of the sympathetic nerve supply to the heart *increases the coronary blood-flow.* The future must decide whether this is due to abolition of vasospastic influences, or to altered conditions of the heart's work. Whatever its cause, the increased flow of blood through the coronary vessels is likely to exert a beneficial effect on the cardiac ischæmia, whether this is intermittent, as in the vasospasm probably responsible for functional angina, or continuous and relative, as in the early stages of coronary arteritis.

Operative interruption of the *motor* or *pressor* sympathetic nerves tends to decrease the motor activity of the heart, in conditions of relative cardiac ischæmia, where it is particularly desirable to prevent the work of the heart from exceeding its limited capacity for muscular effort. Unfortunately, complete motor denervation of the heart is a most formidable procedure, entailing bilateral extirpation of the sympathetic chain, from the superior cervical ganglion down to the fifth thoracic ganglion, and also denervation of the suprarenal medulla (since it has been proved that even small quantities of adrenalin can evoke pressor effects on the denervated heart). Apart from the grave operative risk of such an extensive procedure on a cardiopathic patient, it has the added and serious danger of leaving the heart entirely unable to respond to effort. More limited attacks on the motor sympathetic give little or no benefit, owing to the widespread connections of the motor fibres.

Interruption of the sensory sympathetic paths (see page 3942) is free from these drawbacks, gives the most dependable results, and is rapidly becoming the established method of attack in cardiac neurosurgery. Cardiac sensation can be largely abolished by effective division of the sensory pathway, and angina, and other forms of heart pain, can be cured or relieved, without in any way impairing the heart's efficiency, or its ability to respond to effort.

Sir James Mackenzie objected to the surgical treatment of angina pectoris on the ground that by abolishing pain it would remove an important warning signal against effort beyond the heart's limited capacity. This objection has not proved valid, as in actual practice cardiac sensation is rarely abolished to such an extreme degree, and warning signals of some kind still occur when anything like dangerous effort is indulged in. A striking proof of this is given by White in his admirable monograph on the sympathetic system published in 1935 : *a number of angina cases were treated by complete sensory denervation* on the left side, with the result that anginal pain and all cardiac sensations were abolished to the left of the mid-line, but danger signs in the form of slight right-sided pain and vasomotor phenomena in the face or abdomen still occurred in the presence of effort. As a matter of fact, most failures after neurosurgical treatment for angina have been due to a too limited sensory denervation, and the dangers of too complete an interruption are undoubtedly less serious than some people would have us believe.

Although we have discussed the nerve surgery of the heart on the basis of its three distinct forms of nerve supply, in actual fact it is *impossible to perform a successful neurosurgical operation which* limits itself to the vasomotor, pressor, or sensory innervation only. Any sympathectomy sufficiently extensive to be of service is bound to interrupt all three forms of cardiac innervation, although it is true that they may not be interrupted to an equal degree. The results of surgical intervention depend partly on the proportion in which the three forms of nerve supply are interrupted, and partly on the degree of such interruption. When it is added that the anatomical arrangement of the cardiac nerves and their connections is subject to considerable variation, as is also the anatomical knowledge and surgical skill of operators, it becomes easy to see why the results claimed for the numerous and often dissimilar surgical procedures are so inconsistent and confusing.

An attempt to extract the more successful neurosurgical operations on the heart from the large list of attempted procedures leaves the following small group for further consideration. It should first be noted

that, while the best results of neurosurgery are obtained in cases of early and uncomplicated or functional angina pectoris (angina simplex), in which the outstanding lesion is probably an intermittent coronary vasospasm, some relief and amelioration can be expected even in the presence of early organic coronary disease with relative cardiac ischæmia. These latter cases, however, are far more suitable for the more modern procedures of thyroidectomy and Beck's grafting operation. Surgical treatment must be *carefully avoided* in cases of *hysterical* angina or pseudo-angina.

The following operations are all directed to the cervico-dorsal sympathetic system, and for a description of *operative technique* the reader is referred to the article on the Sympathetic Nervous System in Vol. II, page 3099.

1. *Complete Cervical Sympathectomy.* This is the procedure suggested by Franck, and performed and warmly defended by Jonnesco. The operation may be done on the left or on both sides, and in one stage or two. Its object is to remove the entire cervical sympathetic chain, down to and including the stellate or 1st thoracic ganglion. Before 1926, bilateral complete cervical sympathectomy was the most effective method of cardiac denervation we had; in fact, until about that date it was believed that this procedure interrupted almost all the central connections of the cardiac plexus. We now know that, although it abolishes most of the motor and vasomotor sympathetic fibres, a variable but large proportion of the sensory connections are left untouched. In spite of this it is quite certain that the operation cures or relieves a considerable percentage of cases submitted to it. Its great drawback is a *high mortality*, to which attention was drawn by Danielopolu, and which has stood in the way of the procedure ever becoming really popular. Leriche and Fontaine attribute this mortality to the trauma and shock caused by speedy and rough operative technique, and believe that with more gentle and slower operations the risk could be greatly lowered. We doubt, however, if the danger of such a huge procedure could be anything but great in a patient with a cardiac disorder. The operation is tedious and difficult, particularly in short-necked individuals, and has now been replaced by simpler and safer procedures.

2. *Suprastellate Sympathectomy.* The high mortality of Jonnesco's operation led to the introduction of more conservative procedures. Thus, in 1923, Coffey and Brown claimed to relieve some cases of angina by *resection of the superior cervical ganglion.* This is above the level of sensory connections (see page 3943), and any benefit which results must be attributed to division of motor or vasomotor fibres only. In 1927,

Danielopolu recommended a very conservative operation which amounts to a *post-ganglionic ramisectomy*. Both procedures spare the stellate ganglia and the thoracic connections of the cardiac sympathetic, and completely preserve the efficiency of the heart. But there is no evidence that removal of the stellate ganglia impairs the cardiac efficiency, and the scope of these conservative operations is far too limited, and their results too uncertain, to justify their retention. An exception might perhaps be made in short-necked patients, in whom resection of the upper and middle ganglia may be less difficult and dangerous than stellectomy.

3. *Stellectomy*. The effects of stellectomy can be imitated by infiltration of the stellate ganglia with novocaine. Leriche and Fontaine claim to have performed *novocaine stellate block* a hundred times, and to have obtained instant though temporary arrest of anginal and asthmatic crises. They recommend it in the treatment of *anginal attacks* which resist the usual medical measures. Since it does give a definite chance of relief, and also diminishes the tendency to fibrillation during a severe crisis, it is certainly worthy of trial.

Resection of the left or of both stellate ganglia may at the moment be regarded as the best of the operative sympathectomies for the permanent relief of angina. It is almost as effective as Jonnesco's complete cervical sympathectomy, and it is safer. Leriche and Fontaine report 70 per cent of good results after stellectomy for angina, but with certain other operators the figure is nearer 50 per cent. Its success or failure must largely depend on the anatomical arrangement of the sensory cardiac nerves. When the operation succeeds, it does so because the bulk of the afferent fibres pass through the stellate ganglia, but it is bound to fail when the thoracic cardiac nerves (see page 3943) carry a large proportion of the sensory nerves. Preliminary novocaine block during an anginal attack should assist us in distinguishing between these two types of sensory pathway, and may thus give valuable information of the likelihood and degree of relief which can be expected from a stellectomy.

4. *Alcohol Injection of Upper Thoracic Ganglia and Rami.* The frequent failure to abolish cardiac pain by cervical and stellate sympathectomy led to the anatomical discovery that post-ganglionic fibres reach the cardiac plexus from the upper five thoracic sympathetic ganglia, as well as from all three cervical ganglia, and that sensory impulses reach the cord only by the upper five thoracic white rami. This discovery was soon followed by a transference of surgical attack from the cervical to the thoracic ganglia and rami. *Surgical resection* of the upper thoracic ganglia was tried with absolute

provided the cardiopathy has been definitely ameliorated, very slight bodily activity may be begun, and most gradually and carefully increased. The rest of the treatment consists of careful regulation of bodily activity and thyroid administration; the object is to find and keep an optimum level, in each patient, which will maintain the hypothyroid state, without myxœdema or an unnecessarily vegetative existence, on the one hand, and without threatened return of symptoms or signs of decompensation, on the other.

Results and Indications. The published results of thyroidectomy show that the operation is, on the whole, more successful in selected cases of congestive failure than in cases of angina and coronary occlusion. Of the 75 cases published by Blumgart and his associates, 25 were cases of angina and 50 of congestive failure. Blumgart's angina results show a mortality (post-operative) of 8 per cent, complete relief in 35 per cent, partial relief in 50 per cent, and failure in 15 per cent. The figures of 29 cases of angina published by Cutler and Schnitker are very similar. Blumgart's 50 cases of congestive failure show the following results: operative mortality of 12 per cent (none in the last 22 cases), subsequent mortality (within 10 months) of 13 per cent, marked improvement (return to work) in 55 per cent, partial improvement in 13 per cent, and failure of 7 per cent. Considering that this last group were all cases with actual congestive failure, many of them with considerable decompensation, and all incapacitated from work prior to operation, these figures are, to say the least extremely encouraging.

It is, indeed, in the treatment of *early congestive failure* that we feel the future of total thyroidectomy lies. Angina can be relieved by effective neurosurgery, while coronary occlusion will before long probably find its cure in grafting operations, but the large group of patients with a failing rheumatic heart cannot be benefited by either of these procedures, and the only hope of relieving their distress, prolonging their lives, and perhaps restoring them to a useful degree of activity, at present lies in thyroidectomy.

The operation is by no means free from danger, and Blumgart himself admits that it should be abandoned in favour of paravertebral alcohol injections (or other treatment) in old patients with coronary thrombosis and cardiac pain, in cardiopathies associated with syphilitic aortitis and aortic regurgitation, and in all cases with a low basal metabolic rate. It would probably be wise to add to this list all cases of [illegible] angina, and

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success so far as the relief of cardiac pain was concerned, but it proved much too dangerous a procedure for patients with coronary disease.

Following the example of Mandl of Vienna, *paravertebral alcohol injections* into the upper thoracic ganglia and rami began to be given, and soon proved very successful in abolishing cardiac pain, and comparatively free from danger to life. Lists of successful cases were published by several clinics, while recently (1935) the procedure has been extensively tried and warmly advocated by J. C. White of Harvard. He analyses results in 40 patients, all with intense cardiac pain unrelieved by medical measures, many with severe relative ischæmia or even coronary thrombosis, and some with actual congestive failure; his figures show one operative death, nearly 70 per cent cures (90 to 100 per cent relieved), and nearly 20 per cent good improvements (relieved 50 per cent or more). The failures he attributes to imperfect injection and gives convincing evidence in support of this contention.

Were it not for its *technical difficulty*, and for the unpleasant *complications* to which it is liable, paravertebral alcohol injection would by now have replaced every other form of sympathetic neurosurgery. Unfortunately, accurate injection at a depth of two to three inches, of structures so small and so hidden as the sympathetic ganglia and white rami, is bound to be technically very difficult, and requires long and careful study and practice. Of the *complications*, apart from the failures, the most common is an *intercostal neuritis*. The alcohol injection permanently destroys the sympathetic rami, but only temporarily anæsthetises the thicker and more strongly sheathed intercostal nerves; after two or three weeks' anæsthesia the intercostal nerves pass on to an irritative neuritis, which may be slight and short-lived, but is sometimes severe and prolonged. Among less common complications are *pneumothorax*, due to pricking of the lung, and *pleuritic pain*, caused by scratching of the pleura.

Because of the technical difficulty of a successful injection, and the liability to troublesome intercostal neuritis, we feel that the alcohol treatment should be reserved for cases of severe anginal pain which, because of coronary disease or threatening failure, are poor operative risks for stellectomy, thyroidectomy or grafting operations. It is hardly necessary to add that it should be employed only by surgeons who thoroughly understand the technique of its administration. For a full description of this technique the reader is referred to the excellent monograph by J. C. White on the *Autonomic Nervous System* (1935) to which we have already alluded. A brief account will be found in Vol. II, page 3198.

OPERATIONS FOR DISORDERS OF CARDIAC RHYTHM

Essential or paroxysmal tachycardia is a distressing disturbance of the pace-making mechanism of the heart, and is usually controlled by medical treatment. Occasionally, medical treatment fails to stop or abort the attacks, which may become so severe as to bring on congestive failure of the heart. Stellectomy has been suggested for such cases by Leriche and Fontaine, who claim one cure $7\frac{1}{2}$ years after operation. On the other hand, J. C. White investigated two cases by injecting novocaine into the upper thoracic ganglia, in one of which the heart rate was brought down from 210 to 83 for three weeks ; he believes, however, that in children, at least, ganglionectomy should be preferred to alcohol injections.

Leriche and Fontaine go so far as to suggest that sympathectomy may be tried in Stokes Adams' *bradycardia,* in the belief that by improving the coronary blood flow we might influence the conducting system of His. Assuming, however, that bradycardia is a manifestation of coronary deficiency, it is more likely to be influenced by operations more definitely directed to the blood supply of the heart.

THYROIDECTOMY IN TREATMENT OF CARDIOPATHIES

Although only three years have elapsed since the normal thyroid was first extirpated for heart disease, the operation is now firmly established as a measure of real therapeutic value. Even in this short period it has been possible to form an opinion of the usefulness of the operation, of its indications, and of its results. The pioneer work of Blumgart, Levine and Berlin has already been referred to (see page 3973), and in the last two years further publications by them, Cutler, and others, have done much to bring this valuable procedure to the notice of the surgical world.

It has been known for many years that the removal of a toxic thyroid may benefit materially any associated cardiac lesion, but the extirpation of the normal thyroid is done for a different reason, viz., to ease the work of the heart by lowering the general metabolism. When first tried for this purpose the thyroidectomy was sub-total, but this soon proved of little or no service. Total thyroidectomy, however, produced very striking relief in both angina pectoris and early congestive failure of the heart. The actual results differ materially in these two cardiopathies, as might indeed be expected from their quite dissimilar pathology ; but, in general, cardiac pain and distress in the first, or the congestive phenomena of decompensation in the second, may be

expected to diminish or disappear when the basal metabolic rate falls *to minus 20 or 25.* Usually it takes from three to four weeks for this fall to be fully established. The maintenance of this low level of metabolism will not be disturbed by the minute doses of thyroid extract which have to be taken to avoid myxœdema.

The experience of the last three years has shown that thyroidectomy must not be regarded as a panacea for all sufferers from serious heart disease. The attempt to accept and apply the operation in any such sense can only ultimately discredit a procedure which, within proper limits, is capable of conferring very real and lasting benefit. In a recent publication Mixter, Blumgart and Berlin emphasise three points, observation of which is essential to success: (1) pre-operative study and careful selection of cases, (2) special operative technique and post-operative care, and (3) accurate interpretation of the results, comparison of what is expected with what is gained, and derivation of the indications and contra-indications for the operation from the knowledge thus obtained. *It is under these headings that we shall endeavour to present* an outline of this important procedure.

Pre-operative study and selection. Surgery should never be employed as an agent of euthanasia, and no case should be submitted to operation owing to the failure of medical treatment, unless there is a reasonable chance of recovery. The somewhat high immediate mortality which first attended the operation led to a more careful pre-operative study of cardiopathic patients, and a closer co-operation between the physicians and surgeons in charge, with the result that careful *selection of cases* was soon found to be the most important factor in success. It is now known that cases of advanced congestive heart failure, in which decompensation exists to the degree of serious pulmonary congestion, and which fail to respond to a period of complete rest and medical treatment, will not improve after thyroidectomy, and are likely to die from it. We also know that patients with a low basal metabolic rate (minus 10 or less) are unlikely to derive any benefit from it, and that cases of coronary thrombosis make bad operation risks. It has further become obvious that although thyroidectomy may considerably relieve the distressing symptoms of angina and other coronary cardiopathies, its best results are obtained in early congestive failure.

Another factor of great importance is the *anæsthesia.* Many of the early operative deaths occurred under general anæsthesia, and there can be no question whatever that the operation should only be performed with local novocaine infiltration. The strongest possible [illegible]ort of this is given by Mixter, Blumgart and Berlin, who repor[illegible] their last

22 cases of congestive failure were operated on under local anæsthesia without a single operative fatality. The same authorities advise against the administration of more than a minimal quantity of sedative drugs, both before and after the operation, on the ground that thereby the cough reflex is not abolished, and the patient is protected against the very real danger of post-operative pneumonia.

Operative technique. The median approach, by dividing the isthmus and removing the two lobes separately, has been abandoned as too dangerous, and the usual thyroidectomy approach is employed. After infiltrating the tissues in front and to each side of the gland, a long collar incision is made a full inch above the sternum, down to the infra-hyoid muscles. These are split from the larynx to the sternum and widely separated. The previous novocaine infiltration will now prove helpful by separating the tissue planes, and facilitating the isolation and removal of the gland. Care must be taken not to infiltrate the tracheo-œsophageal groove, as this may cause recurrent laryngeal paralysis; serious results may occur if both nerves are blocked. The superior thyroid vessels are now divided and the upper poles of the gland mobilised; the other vessels are then tied and cut as near as possible, to the gland which is gently enucleated from its surroundings. By keeping very close to the gland the dangers of injuring the recurrent laryngeal nerve, and of removing the parathyroids, are considerably diminished. Blumgart and his associates do not regard these dangers very seriously, although they admit that mild tetany may occur, and that paralysis of one vocal cord from injury of the recurrent is a reason for stopping the operation at a hemi-thyroidectomy. But Cutler and Schnitker appear to consider these accidents as quite likely, and insist that the recurrent laryngeal should be actually seen at the operation, to safeguard it against injury, and that very special care should be exercised to avoid removal of the parathyroids.

The post-operative care of the patient should be shared between the physician and the surgeon. The most strict supervision, bodily rest, and medical treatment must be continued until anginal symptoms have cleared up, or until there is evidence of good cardiac compensation. In congestive failure the operation lowers the demand made upon the heart, and by comparison raises the supply of cardiac activity; thus a state of decompensation gives place to one of compensation. The success or failure of the operation will not be apparent until the basal metabolic rate has been reduced to the necessary level to give real relief to cardiac effort, i.e. about minus 20, and this does not usually occur until the third or fourth week. When this stage is reached, and

provided the cardiopathy has been definitely ameliorated, very slight bodily activity may be begun, and most gradually and carefully increased. The rest of the treatment consists of careful regulation of bodily activity and thyroid administration; the object is to find and keep an optimum level, in each patient, which will maintain the hypothyroid state, without myxœdema or an unnecessarily vegetative existence, on the one hand, and without threatened return of symptoms or signs of decompensation, on the other.

Results and Indications. The published results of thyroidectomy show that the operation is, on the whole, more successful in selected cases of congestive failure than in cases of angina and coronary occlusion. Of the 75 cases published by Blumgart and his associates, 25 were cases of angina and 50 of congestive failure. Blumgart's angina results show a mortality (post-operative) of 8 per cent, complete relief in 35 per cent, partial relief in 50 per cent, and failure in 15 per cent. The figures of 29 cases of angina published by Cutler and Schnitker are very similar. *Blumgart's 50 cases of congestive failure show the* following results: operative mortality of 12 per cent (none in the last 22 cases), subsequent mortality (within 10 months) of 13 per cent, marked improvement (return to work) in 55 per cent, partial improvement in 13 per cent, and failure of 7 per cent. Considering that this last group were all cases with actual congestive failure, many of them with considerable decompensation, and all incapacitated from work prior to operation, these figures are, to say the least, extremely encouraging.

It is, indeed, in the treatment of *early congestive failure* that we feel the future of total thyroidectomy lies. Angina can be relieved by effective neurosurgery, while coronary occlusion will before long probably find its cure in grafting operations; but the large group of patients with a failing rheumatic heart cannot be benefited by either of these procedures, and the only hope of relieving their distress, prolonging their lives, and perhaps restoring them to a useful degree of activity, at present lies in thyroidectomy.

The operation is by no means free from danger, and Blumgart himself admits that it should be abandoned in favour of paravertebral alcohol injections (or other treatment) in old patients with coronary thrombosis and cardiac pain, in cardiopathies associated with syphilitic aortitis and aortic regurgitation, and in all cases with a low basal metabolic rate. It would probably be wise to add to this list all cases of severe angina, and those of arteriosclerotic and hypertensive heart disease, and to reserve thyroidectomy particularly for patients with early *congestive failure and without severe cardiac pain.*

REVASCULARISATION OF THE HEART BY OPERATION

The great frequency of occlusive disease of the coronary arteries, its painful and distressing manifestations, and its inevitably fatal termination, often appallingly sudden, makes it the most dreaded of cardiac disorders. It attacks people in the prime of life, and shows a special predilection for men of intelligence and industry, and for experienced professional, commercial and social workers, when they can least be spared. Medical treatment cannot do more than alleviate some of the distressing symptoms and perhaps postpone for a while the inevitable end, but at times it fails even to do this much. Neurosurgical operations and total thyroidectomy often give more marked and more permanent relief, and they may delay the fatal termination for a longer period; but in the nature of things they can never be really curative, since they cannot completely arrest the organic processes which deprive the heart muscle of the blood supply necessary to the maintenance of its function.

Sooner or later surgical art was bound to attack the problem of coronary occlusion at its root, by providing a new blood supply to the ischæmic heart muscle, and the name of Claude Beck will go down to posterity as that of the man who made the first successful attempt to do this on a human subject. Whether his operation will stand the test of time, or whether it becomes in due course replaced by other and simpler or more satisfactory procedures, the first great step has been taken, and the tenacity and initiative of surgeons may be trusted to improve and widen its principles and scope, until this surgical achievement becomes equal to the tremendous need for it.

The heart is defenceless against the interruption of its normal blood supply, because the serous sac which encloses it deprives it of the chance of acquiring an adequate external collateral supply. The only continuity between the coronary circulation and extracardiac structures is provided by the scanty fat and other avascular tissues on the walls of the great vessels. In extremely exceptional cases even this poor scaffold for an extracardiac anastomosis is capable of development, as is shown by the survival of a few cases with complete occlusion of one or even both coronary arteries, but the occlusion has to occur so very slowly that it is not surprising to discover that such cases are absolute rarities. In the vast majority, death occurs long before any external anastomosis even begins to function.

Bringing the surface of the ischæmic heart into direct contact with an extracardiac vascular bed is the obvious solution of this problem.

both procedures are in the stage of trial, and that only future experience will decide whether one or the other, or perhaps some method as yet undiscovered, will ultimately prove the best.

Beck's Muscle-grafting Operation. Beck's first attempt to revascularise the human heart was a complete success. The operation was performed in February 1935, on a man of 48 with severe anginal attacks, moderate hypertension and arteriosclerosis, and a generally typical picture of coronary sclerosis. Under gas and oxygen anæsthesia the insertion of the left pectoralis major was mobilised, and a curved incision made to the left of the sternum. A pedicled flap was cut from the lower part of the pectoral muscle (fig. 2184), while the upper part of the pectoral was incised a little lateral to the sternum and lifted from the 3rd, 4th and 5th cartilages. These cartilages were then removed, and the intercostal muscles divided laterally, preserving their internal mammary supply. The pericardium was opened from apex to base (fig. 2185), and its serous lining, as well as the epicardium, removed in shreds with a burr. This caused extra systoles and some cardiac dilatation, which necessitated rest periods. The pedicled graft was then split, and both parts wrapped round the heart, and sutured laterally and posteriorly to the parietal pericardium (fig. 2186). The intercostal muscle bundles, carrying the internal mammary artery, and the inner margin of the pectoral muscle were brought beneath the sternum and also attached to the pericardium. Finally, the lateral margin of the pectoral was turned in so that its cut surface touched the heart (fig. 2187), and the pectoral fascia and skin wound were sutured without drainage.

Seven months after the operation the patient claims that he is cured. He has had no precordial pain or distress, and is able to work as a gardener. In an addendum to his article Beck reports six additional operations, making seven in all. His second patient died after a week from thrombosis of the bifurcation of the aorta. The third had had a total thyroidectomy performed 18 months previously and was practically bedridden; at operation the sclerosed and tortuous coronary arteries could be palpated; in less than 3 months he was able to take double the amount of thyroid, to bring up his B.M.R. from minus 20 to plus 2 without any pain, and to spend 6 to 8 hours out of bed daily. The other patients survived the operation, but a sufficiently long interval had not elapsed to comment on them.

tendon of the diaphragm, pulled the omentum into the pericardial cavity, destroyed the epicardium with iodine, and wrapped the omentum round the heart, fixing it *in situ* with two sutures. Three to *six weeks later he ligatured the left coronary at its origin. All the dogs* survived and showed no disturbance of cardiac function, while control animals without the *omentocardiopexy* invariably succumbed. At a subsequent operation extensive adhesions were found between the omentum and heart, which bled profusely when slightly separated. It should be observed that Rienhoff used old dogs for his experiments, and it may be this, rather than the different vascular bed employed, which explains the greater protection he obtained against one-stage occlusion of a main coronary trunk.

In January 1936 O'Shaughnessy published in the *British Journal of Surgery* a series of experimental omentocardiopexies on cats and dogs, with very similar results. He showed that injection material reached the myocardium from the omentum. It is interesting to note that one of his animals died from a strangulated hernia of the intestine, which had passed into the thorax through the diaphragmatic *opening.*

Beck's, Rienhoff's and O'Shaughnessy's experiments prove quite conclusively that the ischæmic heart can acquire a collateral circulation, provided it is brought into contact with a vascular bed, and that this may prove adequate to meet the heart's needs. An obvious question which arises is whether or not the adhesions between the heart, on the one hand, and the pericardium, skeletal muscle or omentum, on the other, are likely to hamper cardiac movements and function. In the section on adhesive pericarditis it was pointed out that only two types of adhesive process interfere with the heart, viz. fixation to rigid structures, and constrictive adhesions. In the procedures we are now considering neither of these conditions applies, and there is no reason to expect any appreciable cardiac embarrassment.

In the application of these procedures to the human subject two further questions arise. In Beck's operation of muscle-grafting the nerve supply to the pedicled graft is partly destroyed, and this may lead to atrophy and diminished vascularity of one source for the collateral cardiac blood supply; Beck himself, however, does not consider this objection to be valid. The employment of omental grafts (omento-cardiopexy) is free from any such objection, but it involves the creation of an opening in the diaphragm, which may be a cause of subsequent diaphragmatic hernia, or which may by fibrous contraction ultimately lead to strangulation of the omental graft. It must be stressed that

both procedures are in the stage of trial, and that only future experience will decide whether one or the other, or perhaps some method as yet undiscovered, will ultimately prove the best.

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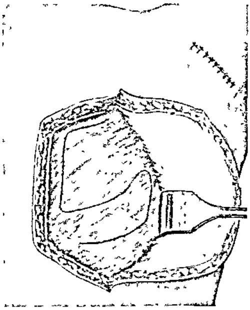

Fig. 2184.—Beck's muscle grafting operation for coronary disease. Stage I. (*Modified from Claude S. Beck.*)

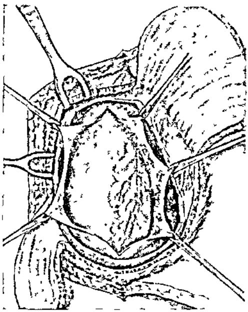

Fig. 2185.—Beck's muscle-grafting operation for coronary disease. Stage II. (*Modified from Claude S. Beck.*)

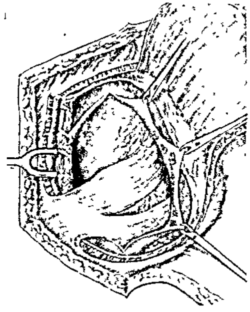

Fig. 2186.—Beck's muscle-grafting operation for coronary disease. Stage III. (*Modified from Claude S. Beck.*)

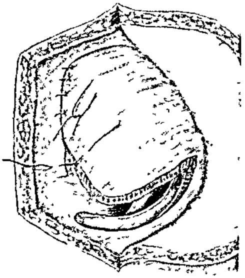

Fig. 2187.—Beck's muscle grafting operation for coronary disease. Stage IV. (*Modified from Claude S. Beck.*)

Tumours of the Heart

Considerably over a hundred cases of tumours and cysts of the heart are on record. The *tumours* are mostly secondary carcinomata, fibromata and rhabdomyomata. Morbid effects may be produced by pressure on the coronary, pulmonary, or other vessels entering and leaving the heart, by interference with the conducting mechanism or the valves, by encroachment on the heart chambers, and by destruction of the myocardium. There is, unfortunately, no recognisable clinical picture, and diagnosis has so far proved practically impossible. *Hydatid cysts* have also affected the heart; diagnosis has not yet been accomplished, but the complication might be suspected in a case of generalised pulmonary hydatid disease with syncopal attacks.

Two instances of surgical intervention are mentioned by Lenormant and Leriche. In one, Leriche himself discovered a sarcoma of the right auricle, while in the other, Lopez found a hydatid of the heart during a search for an alleged mediastinal tumour. Both cases died after an attempt at partial removal of the tumour.

Surgical Treatment of Cardiac Arrest

Nearly all cases of suspended animation which can be treated surgically occur on the operating table and under general anæsthesia. Usually the cardiac arrest is attributable to the anæsthetic, but it is not chloroform which is always responsible. The writer has seen it occur twice with open ether and twice with a short gas administration, all four cases proving fatal. One cannot help expressing the conviction that some cases of total cardiac arrest are directly due to preventable error in anæsthetic technique, and more particularly to inattention on the part of the anæsthetist, and to his failure to inform the surgeon that things are going wrong in time for the latter to apply successful resuscitatory measures.

At the first sign of cardiac arrest (in abdominal operations this is best confirmed by palpating the aorta), the head should be lowered, coramine injected, and the chest slapped, or forcibly compressed over the precordia and suddenly released. If there is no response in under a minute, one or two cc. of 1 in 1000 adrenalin should be injected into the right ventricle through the fourth intercostal space. When the abdomen is open, cardiac massage should be started at once by the surgeon, while his assistants carry out the above measures and

apply artificial respiration; otherwise a left paramedian epigastric incision is made at maximum speed. The right hand is insinuated above the left lobe of the liver, and the heart squeezed rhythmically and methodically through the diaphragm, the precordial region being steadied with the left hand. The adrenalin may be injected through the diaphragm, as it is then more likely to reach the heart muscle instead of being wasted in a cardiac chamber.

The diaphragm should never be incised in performing cardiac massage, and care must be taken not to tear the liver or its ligaments. The trans-thoracic approach is not permissible, as there is never enough time to allow of it. To stand any chance of success the surgeon should be massaging the heart within five minutes of its arrest; the brain centres will not recover after a much longer period of anoxæmia, even if the heart be coaxed to a short return of function.

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CHAPTER II

Surgery of the Veins

VARICOSE VEINS

Ætiology and Morbid Anatomy.

The veins of the lower extremity are arranged in three sets, superficial, deep, and communicating. Of the *superficial veins*, the *long* or *internal saphenous* runs up the inner side of the leg and thigh, to pierce the deep fascia at the saphenous opening, and open into the femoral vein; the *short* or *external saphenous* runs up the postero-external aspect of the leg and enters the popliteal vein. The *deep veins* start as venæ comites accompanying the arteries of the foot and leg, and join to form the popliteal vein, which continues up as the femoral vein. The *communicating veins* perforate the deep fascia of the leg and thigh at intervals, and establish free communications between the superficial and deep veins. All three sets of veins are supplied with valves which, when competent, prevent reversal of the normal direction of the blood-flow.

The upward flow of venous blood is opposed by gravity. With such a long column of blood as is represented by the distance between the feet and diaphragm, the factors responsible for the maintenance of the venous flow operate at considerable disadvantage in the erect posture. This applies particularly to the small propulsive force represented by the difference between capillary and venous pressure, and to the suction effect of the negative pressure in the great veins produced by respiratory and cardiac activity. Indeed, in the upright position, the upward flow of venous blood depends mainly on the contraction of the lower limb muscles. Such contraction pushes the blood in the deep veins upwards, and thus sucks the blood out of the superficial veins, through their junction with the main venous trunks. and also through the communicating veins. For this mechanism to function properly it is obvious that the valves in all three sets of veins must be competent, and that the erect posture, when kept up for lengthy periods, must be combined with muscular exercise.

Recent work with radio-opaque injections by Barber and Orley tends to show that blood does not enter the deep veins through the communicating channels, but as their experiments were performed

on the X-ray table they do not invalidate the above description, which refers to the mechanism of the venous flow under conditions of postural stress.

In the *ætiology* of varicose veins several factors play a part. The chief of these is *venous stasis*, mostly caused by long periods of standing in people of otherwise sedentary habit. The deep veins, well supported by surrounding muscles, are protected from the effects of this stasis, but the superficial veins feel the full brunt of it. Being quite unsupported, and deprived of the suction effect of adequate muscular contraction, they begin to distend with accumulated blood. The rise in intravenous pressure is at first compensated by hypertrophy of the scanty muscular and elastic tissues of the venous wall, and while the valves remain competent the veins may regain their normal size and efficiency if the factors responsible for the stasis are arrested. Continuation of the unfavourable conditions, however, ultimately leads to *incompetence of the valves*, owing to venous distension beyond the limits of valvular closure. A vicious circle is now initiated, more and more valves fail, and the dilated veins lengthen, become tortuous, and undergo degenerative and fibrotic changes in their walls; in other words, they become varicose, and the dilatation is now permanent (phlebectasis). All the layers of the vein wall share in these degenerative changes: the *intima* becomes irregular and loses its resistance to stress, so that thrombosis and phlebitis may result; the *media* becomes thick, and more and more fibrous and rigid, although it is sometimes atrophied and thin; the *adventitia* is involved in the fibrotic process, which may spread beyond the vein and cause it to adhere to the skin.

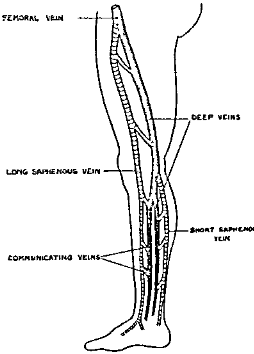

Fig 2188.—Scheme of veins of lower limb.

The superficial veins are no longer able to function properly, and, in the effort to regain efficiency, they may develop into great loops or bundles of vessels, often very thick-walled, but sometimes thin-walled in places. Adjacent loops may communicate to form large venous sinuses, and various morbid changes occur in the veins themselves, and

in the skin and other tissues which they drain. The limb becomes congested and waterlogged, and suffers the effects of blood stagnation. These morbid changes are made worse by involvement of the communicating veins in the varicose process, and by incompetence of their valves.

Two conditions which may be associated with venous stasis, and to which the writer drew attention in a recent paper, are *senile phlebosclerosis and periphlebitis.* The first is a fibrotic hardening of the veins, mostly seen in elderly patients with chronic ulcer of the leg, and occurring quite apart from varices. Periphlebitis is a cellular infiltration of the perivenous tissues which occasionally develops as a result of venous stasis, and is also seen in chronic leg ulcers; the vein itself remains thin-walled and can be felt as a fluid line, sunk into the infiltrated area.

Inherited predisposition also plays an important part in ætiology, and according to Ochsner it can be demonstrated in 75 per cent of cases; not infrequently varicose veins are associated with varicosities elsewhere, e.g. varicocele, hæmorrhoids, etc. This inherited weakness of the vein wall explains the extensive varices sometimes seen in young people, but when the condition occurs in later life it is mostly mechanical in origin. Furthermore, it is significant that phlebectasis and phlebosclerosis may be accompanied by sclerosis of the arteries.

Quite distinct in causation are the varices produced by the pressure of the *gravid uterus*, and of abdominal or pelvic *tumours*, on the iliac veins, and those which form to compensate *thrombosis of deep veins.* The varicose veins of pregnancy cannot be entirely caused by pressure, as they often develop in the early months and may be very widespread.

Clinical Features.

Varicose veins are seen at all ages, but mostly in young adults and middle-aged people. The long saphenous tract is involved in the vast majority, mostly below the knee, but often in the thigh as well; the short saphenous suffers much less, but frequently shows some varicosities. The degree of involvement varies enormously. There may be just a few cyst-like dilatations in the course of the long saphenous: the whole vein may be more or less evenly dilated without bunching or looping; or there may be great tortuosity with masses and loops of distended veins and sinuses. The condition may be limited to the larger veins, or it may involve the small radicles; dilatation of the venules of the skin is responsible for unsightly spider-like and other markings, but is otherwise of no importance.

Many patients experience no symptoms whatever, but seek treatment merely because they have varicose veins. More than half, however,

complain of a heavy *aching* in the legs, and of *fatigue* which comes on with undue rapidity. Occasionally, severe *cramp-like pains* occur which may be caused by inadequacy of the nervous blood supply.

The results of *blood stagnation* then manifest themselves. There is a fall in the oxygen of the local venous blood, and a rise in CO_2, urea, and non-protein nitrogen. The resulting anoxæmia sets up an irritating *dermatitis*, with itching, and areas of *pigmentation*, especially above the internal malleolus. The limb becomes *œdematous* and waterlogged, *lymphatic stasis* ensues and leads to *hypertrophic and sclerotic processes* in the skin, the subcutis and other tissues, and a more or less extensive *ulceration* may be the final result. Another possible sequel is *hæmorrhage* owing to rupture of the atrophied skin over an adherent vein.

Investigations.

Before undertaking treatment, the surgeon should ascertain if the valves in the superficial and communicating veins are competent or not, and if the deep veins are patent or not.

The competency of the superficial veins is determined by *Trendelenburg's test*, to which attention has recently (1934) been drawn by Cooper. With the patient standing, the lower end of the saphenous vein in the thigh is compressed with the thumb, and the blood in it milked upwards: if the vein remains collapsed, the valves are competent and the test is negative; if the vein fills from above, the valves are incompetent and Trendelenburg's sign is positive. The competency of the communicating valves is examined by *Perthé's test*. The saphenous vein is obliterated in the thigh with a blood-pressure cuff, and the patient made to walk about; the muscular activity should suck the blood out of the superficial veins, but if the valves in the communicating veins are incompetent the superficial veins remain full.

To test the *patency of the deep veins*, the superficial veins are obliterated with an elastic bandage from the toes to the knee; the patient is then made to walk for half an hour. If the deep veins are patent, the patient remains quite comfortable and any previous pain subsides, but when the deep veins are thrombosed, the patient will complain of increasing discomfort. The importance of determining the patency of the deep veins is quite obvious, as any attempt to obliterate the superficial veins by injections or other treatment will have disastrous consequences in the presence of deep thrombosis.

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Complications.

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stasis. the blood stagnation. and the resulting local anoxæmia, accumulation of toxic metabolites, and local tissue acidosis.

Associated *skin* changes are perhaps the most striking. *Eczematous dermatitis* (varicose eczema) is a common result and is seen in various types—erythematous, scaly, and weeping; it may be localised, or it may involve the whole of what is known as the "ulcer-bearing area" of the leg (fig. 2189). *Pigmentation* (fig. 2190) occurs in the form of brownish macules which coalesce to form large areas of discolouration, and which may ultimately also occupy the whole of the "ulcer-bearing"

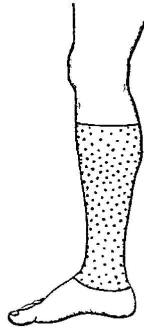

Fig 2189.—Ulcer-bearing area.

Fig 2190.—Chronic ulcer of leg with eczema and pigmentation.
(By kind permission of the "Lancet.")

area. *Pruritus* is very common, and *dermatitis artefacta* may result from scratching. Other common results are *alopecia*, and a *dry* and *hypertrophied skin*.

Œdema of the ankle and lower part of the leg occurs in advanced cases, but quite distinct from this is a *brawny swelling* of the limb which is sometimes seen, and which is caused by hypertrophy of the subcutaneous and deeper areolar tissues owing to lymph stasis. An interesting result of the local hyperæmia, and one to which attention has only recently been drawn, is a *decalcification* of the lower part of the leg bones. *Hæmorrhage* from a ruptured varicose vein has been mentioned already; it is frequently started by injury, and, although easily controlled, it may proceed to an alarming and even fatal degree if unintelligent first-aid measures are employed.

Perhaps the most interesting result of venous stasis is *chronic ulcer* of the leg (fig. 2190). This is a typical indolent and spreading ulcer, often severely painful, and occurring anywhere in the ulcer-bearing area (fig. 2191). It is extremely chronic, starts mostly after the fourth decade, and may grow to a huge size (up to 40 square inches or more). Of 144 cases of indolent ulcer reported by the writer in 1933, only 90 (62·5 per cent) were associated with varicose veins; in the remainder no varices were observed. It follows that varicosity is by no means an

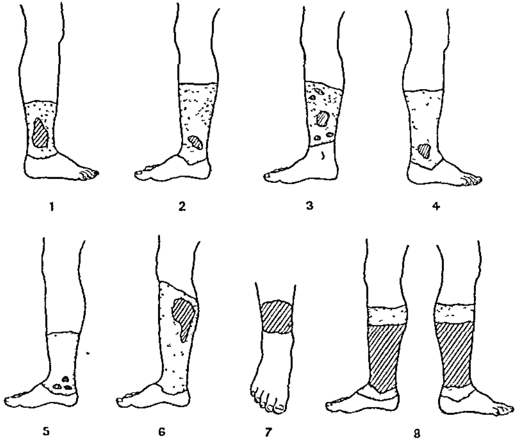

Fig. 2191.—Diagrammatic record of 8 cases of varicose ulcer and eczema.

invariable factor in the causation of the wrongly termed "varicose ulcer"; the essential cause is venous stasis.

There can be no question that varicose veins are liable to attacks of *thrombophlebitis*, but owing to reversal of the blood stream *embolism* is a very rare complication.

Treatment.

For some years varicose veins have been universally treated by the *intravenous injection* of sclerosing substances. The great advantages of this method are that it is extremely safe, and that it does not interfere

with the patient's ordinary life and occupation. The substances mostly used to-day are sodium morrhuate, sodium salicylate, lithium salicylate, and quinine and urethane. They act by damaging the intima, which becomes irregular and "sticky." Thrombosis occurs and plays a part in the early obliteration of the veins, but final obliteration is produced either by organisation of the thrombus or by an adhesive endophlebitis ending in fibrous sclerosis of the vessel. Adhesive obliteration is more permanent than thrombosis as there is less likelihood of recanalisation of the veins. Experimental work shows that destruction of the endothelium reaches its maximum on the fourth or fifth day, while on the sixth or seventh day regeneration begins. This suggests that the injections should be given every five or six days.

Detailed consideration of the *injection treatment* is given in another section of this work (see Vol. II, page 3281), but certain general points may be dealt with here. The most obvious point is that before treatment is started we must make certain that the deep veins are patent; thrombosis in these is an absolute contra-indication to injections. Other *contra-indications* are advanced arterial disease and infective thrombophlebitis; in the former are included thrombo-angeitis and severe arteriosclerosis, in both of which intravenous injections may be the determining cause of gangrene: in thrombophlebitis of infective origin the injection may result in exacerbations of the phlebitis and possibly in *embolism*. Although embolism is an extremely rare complication of injection treatment (Ochsner was only able to collect twenty-eight cases from the literature up to 1932), most cases occur in thrombophlebitic veins.

Of recent years the injection treatment of varicose veins has been the subject of considerable criticism. In the opinion of many there is a high incidence of recurrence, and there is a large group of cases in which injections fail unless they are combined with simultaneous *ligature* of one or more veins. In the last group the valves are incompetent, as shown by the Trendelenburg sign, and the saphenous vein must be ligated at the highest palpable point, before injections are started. This small operation is performed under local anæsthesia, and the patient is allowed to get about at once. Patey recommends *excision* of the long saphenous in the thigh by Babcock's subcutaneous method, by which the vein is divided high up and tied to a special probe, which is pushed down and made to emerge through a small incision lower down; the vein is now pulled out, its tributaries tearing without hæmorrhage, and excised. An injection of 5 cc. of sodium morrhuate is given into the distal end of the vein and the leg bandaged with elastoplast, which is left un-

disturbed for ten days. This procedure is often successful when simple injections fail, and is probably the best treatment for cases with extensive varicose veins involving the thigh as well as the leg. Numerous other operations, once frequently performed, are practically obsolete now.

When the Trendelenburg sign is negative, i.e. when the valves are still competent, injections alone will probably succeed in obliterating most of the varices, but it may be necessary to repeat the treatment after some years.

THROMBOPHLEBITIS

The term thrombophlebitis implies inflammation of a vein and clotting of its contained blood. It is in no sense a clinical or even a pathological entity, but must be regarded as a descriptive term which covers a large number of more or less distinct conditions, conveniently grouped together within the limits of the above definition. With the object of avoiding unnecessary overlapping and repetition, the various conditions will be dealt with here as a group, but it should be observed that they differ considerably in their pathology, clinical manifestations, complications and treatment. The one common factor is that all forms of thrombophlebitis start as an inflammatory lesion of the vein wall, and that thrombosis follows changes in the venous endothelium caused by the inflammation.

Classification and Ætiology.

The large number and variety of lesions grouped under the term thrombophlebitis is shown by the use of such descriptive terms as post-operative thrombosis, puerperal thrombosis, leukæmic thrombosis, pylephlebitis, familial phlebitis, traumatic phlebitis, deep vein thrombosis, superficial phlebitis, sinus thrombosis, phlebitis migrans, essential thrombophilia, etc. A consideration of these lesions on an ætiological basis shows that four factors operate in the causation of thrombophlebitis: (1) infection or other disease of the vein wall, (2) trauma, (3) venous stasis, and (4) altered state of the blood.

(1) *Infection of the vein wall* may be the result of *spread* from a neighbouring *septic focus*. Examples of this are: (*a*) *Pylephlebitis*, in which the mesenteric and portal veins become the site of a suppurative thrombosis, spreading from a septic focus such as the appendix or a sloughing hæmorrhoid, and ending in a portal pyæmia with multiple liver abscesses; (*b*) *lateral sinus thrombosis* (fig. 2192), in which the infection reaches the sinus from the tympano-mastoid cavity, and spreads as a suppurative phlebitis down the jugular vein; (*c*) *cavernous sinus thrombosis*, a very fatal condition produced by spread of pyogenic infection from the upper lip or nose, along the angular vein, or from the

orbit, along the ophthalmic veins; (*d*) *acute osteomyelitis*, commonly associated with a septic thrombosis of the veins in the bone-marrow and Haversian systems, which is particularly dangerous as the veins are held open by adhesion of their walls to the rigid vascular canals; and (*e*) *puerperal thrombosis* of the pelvic and iliac veins, which is a common result of infected labour or abortion. All these varieties of thrombophlebitis are *suppurative*, and can be produced by infection without stasis. They are all extremely dangerous to life, inasmuch as they are frequently responsible for the development of *pyæmia*.

Infective thrombophlebitis also occurs in the course of certain

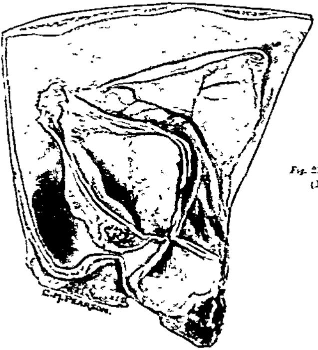

Fig. 2192.—Lateral sinus thrombosis. (*Museum, St. Mary's Hospital.*)

specific fevers, particularly *typhoid*, *pneumonia*, *influenza* and *malaria*. Here, although infection probably plays the larger part, stasis and an altered character of the blood are additional ætiological factors. The phlebitis is usually non-suppurative.

(2) *Trauma* causes a thrombophlebitis which may or may not be infective. In a recent discussion (1936) Dickson Wright drew attention to the thrombosis that frequently accompanies *fractures* of the leg, thigh and pelvis, and to *traumatic axillary phlebitis*, which he attributed to occupations entailing weight-lifting or downward snatching of heavy objects. Infective thrombophlebitis may be caused by *direct infection* through an open wound, by a sting or bite, or from *contaminated injections* for varicose veins.

(3) *Venous stasis* does not in itself produce thrombosis, but it acts as a common and important contributory cause, particularly in *post-operative thrombophlebitis.* According to Ochsner, it is slowing up of the stream, with eddying of blood in the veins, rather than complete arrest, that favours thrombosis; but the direct cause is almost certainly infective. More than 80 per cent of cases of post-operative thrombosis follow operations on the abdomen, particularly on the appendix, gall-bladder and pelvic organs. The stasis of *varicose veins* is another common cause of thrombophlebitis, which in this case is

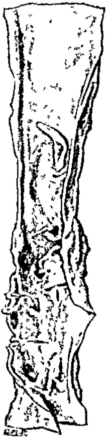

Fig 2193.—Thrombophlebitis of femoral vein. (*Museum, Royal College of Surgeons.*)

Fig 2194.—Thrombosis of femoral vein (*Museum, Royal College of Surgeons*)

usually *superficial. Mechanical obstruction* and *circulatory weakness* are further ætiological factors which operate by causing stasis.

(4) An *altered state of the blood* is responsible for the thrombosis of *leukæmia* and *essential thrombophilia.* It may also account for the cases of *familial phlebitis,* and possibly for the thrombosis that occasionally occurs in syphilis, gout and tuberculosis, although in these *endophlebitis* may be the main causal factor.

Morbid Anatomy (fig. 2193).

This will vary according to the suppurative or non-suppurative character of the inflammation, the variety of the infecting organisms,

thrombosis spreads from the iliac to the femoral vein; Homans believes that the outward spread of the phlebitis obstructs the perivenous lymph channels, but Zimmermann and de Takatz maintain that the perivenous lymphatics are patent, and that the curious nature of the œdema is due to escape of fluid very rich in proteins, owing to extreme permeability of the vessel walls.

The *resolution* of thrombophlebitis comes by subsidence of inflammation and organisation of the clot. Capillary loops grow in from the vasa vasorum in the vein wall and form a cellular granulation tissue which attacks the thrombus and organises it into fibrous tissue. The fibrosis may be complete and lead to permanent obliteration of the vein, which is converted into a solid cord; or part of the lumen may be left, and the shrunken and fibrosed clot become covered with endothelium, thus partly reconstituting the venous channel. Old thrombi are often *calcified by deposition of lime salts, to form phleboliths*; these are prone to develop in varicose veins, usually near a valve.

Clinical Features.

These again are extremely variable. Some *constitutional disturbance* is usual, but it will vary from a mild fever with slight malaise, to a high swinging temperature, with rigors and other symptoms of pyæmia. Leucocytosis is common, especially when deep veins are affected.

The *local symptoms and signs* are obvious in superficial phlebitis, but may be very obscure in deep-seated venous infection. *Pain* is constant; it is of a dull, throbbing nature, and is made worse by movement. There is *tenderness* along the course of the vein, which, if accessible, can often be palpated as a *hard cord*. In superficial phlebitis, mostly affecting the saphenous veins, there is marked *redness*, infiltration and tenderness along the course of the vein. Pitting *œdema* is a prominent symptom, especially in deep thrombosis, in which also there may be *dilation of superficial veins*, and considerable *loss of muscular function*. Occasionally there is some congestion or cyanosis of the skin, and its temperature is sometimes raised by as much as two or three degrees Centigrade.

Prognosis and Complications.

The *prognosis* varies with the site, cause, and virulence of the infection, and the resistance of the patient. It is excellent in superficial and traumatic phlebitis, good in post-operative thrombosis, serious in lateral sinus infection, osteomyelitis and all forms of suppurative thrombosis, and very bad in cavernous sinus thrombosis, pylephlebitis, and puerperal thrombophlebitis.

The most serious *complication* is *pyæmia*, whether this is systemic or portal. Massive *pulmonary embolism* is a less common but even more fatal complication. Less serious forms of *embolism* also occur, and they may cause *infarction* or *metastatic infections*, without a generalised pyæmia; thus, small emboli may lodge in the lungs and cause single or multiple *pulmonary infarcts*, often diagnosed as pneumonia, especially when they occur after operations.

Another complication is *persistent œdema*, which is an occasional result of axillary thrombophlebitis, but is more often seen after a femoral thrombosis. It is probably caused by a combined venous and lymphatic obstruction.

Treatment.

Only general principles can be dealt with here, but a more detailed description will be found under special types of phlebitis. *Prophylactic treatment* is of the utmost value and may be summed up in one sentence: avoid infection and trauma, and prevent venous stagnation. This particularly applies to abdominal operations, where absolute asepsis and gentle manipulation will do much to diminish the incidence of post-operative femoral thrombosis. It is well known that rough manipulation of the abdominal wall is likely to injure the deep epigastric veins, and that this may initiate a thrombophlebitis which spreads to the femoral vein. Avoidance of post-operative stagnation is equally important: early sitting up, deep breathing, and bed exercises will do a great deal in this direction. The blood stream can be accelerated by judicious administration of thyroid extract. Attention has recently been drawn to the value of a high protein diet, especially in patients with a personal or family history of phlebitis. Thrombophlebitis in varicose veins may be prevented by controlling venous stasis with exercise and elastic support.

The treatment of *established* thrombophlebitis is carried out mainly along *conservative* lines. In general, it consists of absolute rest of the limb, elevation, and an ample cotton-wool dressing, with a cradle to keep the limb warm and protect it from injury. For phlebitis below the knee, firm support with elastoplast bandages undoubtedly shortens the course of the disease and diminishes the tendency to upward spread. The duration of the rest period varies with the vein involved, but in general it should continue until all constitutional and local signs of inflammation have completely disappeared.

Constitutional measures are of doubtful value, apart perhaps from *thyroid* therapy, which appears to have a definite influence in limiting the spread of post-operative thrombosis. It is quite usual to give large

doses of *citrate,* but it has recently been suggested that *in vivo* citrate increases instead of diminishes the coagulability of venous blood. There can be no doubt, however, that coagulability is lowered by *hirudin,* and, based on this fact, the leech treatment of phlebitis has recently been revived. Used carefully, this does seem to relieve pain and œdema, but it is doubtful if it exerts any lasting effect on the lesion.

Operative treatment is indicated as a life-saving measure in *acute pyogenic thrombophlebitis,* its object being to avert pyæmia and metastatic embolism. It is usually wise to remove or drain the *infecting focus,* e.g. the appendix in pylephlebitis, or the mastoid in lateral sinus thrombosis; but there is one region where active surgical intervention is to be strongly deprecated, and that is the territory drained by the *cavernous sinus.* This particularly applies to infections of the *upper lip,* in which muscular activity, and the inability of the veins to collapse, make an ascending thrombophlebitis, with extension to the cavernous sinus, particularly likely. The writer has seen four fatal cases of cavernous sinus thrombosis result from septic lesions of the upper lip which were treated by free incision and drainage.

Proximal ligature of the vein, well to the cardiac side of the thrombus, is a valuable procedure in some cases, and has been in use since the middle of the last century. It has been practised on the following veins: jugular, angular (facial), femoral, axillary, mesenteric, iliac and ovarian. Although occasionally performed for non-suppurative thrombosis of both superficial and deep veins, we feel strongly that it should be reserved for cases of *suppurative thrombophlebitis,* its sole object being to prevent pyæmia and septic embolism. The value of ligature and drainage of the internal jugular vein in the neck for lateral sinus thrombosis is beyond dispute, and there can be no doubt that suppurative thrombophlebitis in the limbs should also be treated by proximal ligature, with free opening of the vein and turning out of the infected clot. Ligature of the angular vein, with the object of protecting the cavernous sinus in infections of the face, is of more doubtful usefulness, but it is certainly worth trying. The same applies to ligature of the portal and mesenteric veins, although here the chief difficulty lies in getting above the pus. The writer has had no experience of proximal ligature for puerperal pelvic thrombosis, but the procedure has been recommended for cases which have recovered from the acute stage; best results are said to be obtained when both ovarian and both internal iliac veins have been ligated.

Quite recently, Neuhof advised complete *excision* of accessible veins which are the site of septic thrombophlebitis, on the ground that

proximal ligation is a temporising method, and that complete eradication of the infected vein gives the best hope of avoiding pyæmia or septicæmia, and of saving life when these blood infections have become established.

SOME SPECIAL TYPES OF THROMBOPHLEBITIS

Traumatic Thrombophlebitis of Axillary Vein.

First recognised some fifty years ago, this condition has attracted considerable interest recently. Although there may be a predisposing cause, such as essential or familial thrombophilia, there can be no doubt that the condition is traumatic in origin. As already mentioned, weight-lifting or downward snatching of heavy objects are types of causative muscular trauma, but in some cases quite trivial muscular effort seems to be responsible. It has been suggested that the pull of the subclavius, with the arm in abduction, may rupture a valve or damage the intima, and that endophlebitis and thrombosis result. The writer recently saw a case in which there was no history of preceding trauma.

The right arm is affected almost exclusively, and the attack usually starts quite suddenly with pain and complete disability, immediately or shortly after a muscular effort. Swelling and cyanosis of the arm follow, although in some cases there is pallor. The swelling is firm and spreads to the whole limb. Sometimes a tender solid cord may be palpated in the axilla. but there is no fever or signs of inflammation.

The duration of the attack is usually a few weeks, but recurrence is not uncommon and persistent œdema may be the ultimate result. The *treatment* consists of rest, elevation, and proper support with an elastoplast bandage from the hand to the axilla. Should the condition persist or recur, Matas advises exploration of the axillary vein and resection of the thrombosed segment; he attributes the good results to vasodilatation of the vein produced by removal of the sympathetic plexus around the resected segment.

Deep Thrombophlebitis of Leg.

Femoral thrombophlebitis has been dealt with in some detail already (see Vol. I, page 1256). It is encountered as a *post-operative* complication, in *puerperal* infections, following *specific fevers*, and as an *ascending thrombosis* from the deep or superficial veins of the leg. The left side is more commonly affected, because venous stasis is favoured by the fact that the left iliac vein is crossed by the right iliac artery, and also because the left iliac vein is covered by the sigmoid colon. Although usually of infective origin, femoral thrombosis is mostly non-

suppurative. Diagnosis is rarely difficult, and treatment is conducted along the lines given on page 4002.

Thrombophlebitis of the tibial veins is treated in a similar way, but upward extension may be stopped by firmly bandaging the limb from the toes to the groin with elastoplast. Provided this precautionary measure has been successful, the patient may be allowed to get about after two or three weeks, but the elastoplast should be continued whilst any swelling remains.

Superficial Phlebitis of Leg.

This is mostly seen in varicose veins, particularly in the *long saphenous*, and there can be little doubt that some cases can be attributed to injection treatment, the sclerosing agent lighting up dormant bacterial infection. According to Dickson Wright, the condition is sometimes due to focal sepsis, and he discriminates between a mild or localised type and an ascending type. *Diagnosis* is easily made. There is little general reaction, and the local signs (pain, tenderness and redness) are usually quite obvious; the thrombosed veins can be felt as tender cords. There is little œdema unless the deep veins are involved as well, which is an unlikely event.

The *treatment* is governed by the fact that superficial phlebitis is a safe lesion in an ambulant patient, but becomes dangerous when the patient stays in bed (Dickson Wright). The affected veins should be firmly strapped with elastoplast, under which rubber sponges should be applied at the upper end of the thrombi, to prevent the clot from slipping upwards. Moderate exercise is encouraged from the start. The attack may be expected to subside within a fortnight.

Phlebitis of the *external saphenous* is more dangerous, as it is more likely to spread to the deep veins via its junction with the popliteal vein. For this reason, ligature of the vein, just before it pierces the popliteal fascia, may be worthy of consideration.

Thrombophlebitis Migrans.

Recognised only in the last few years, this condition is of considerable interest. Thrombophlebitis occurs in various veins, together or successively, but with no obvious relationship. It can be an extremely painful condition, and large doses of morphine may be needed to give relief. Pulmonary complications sometimes occur from thrombophlebitis of small pulmonary veins. No organisms are found, and the condition is not unlike Buerger's thrombo-angeitis obliterans; indeed, it is sometimes associated with it.

The disease never seems to be fatal, and complete recovery is the rule, but some cases seem to drag on for months, or even years. Such cases might be greatly benefited by a holiday, or by spa treatment.

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CHAPTER III

Injuries and Surgical Diseases of Arteries

Arterial Injuries

Arterial injuries vary from a contusion to a complete rupture or division. They may be open or subcutaneous. An arterial wound can be incomplete or complete, transverse or longitudinal, clean cut or lacerated. The injured artery may be small, medium-sized, or large. The arterial injury can be associated with fatal hæmorrhage, with negligible hæmorrhage, or with no hæmorrhage at all. The injury may involve the artery alone, it may implicate the accompanying vein, or it may also involve other tissues, such as nerves, tendons, bones, joints and viscera. It is thus obvious that it is almost impossible to deal with arterial injuries as a single clinical entity. Since the subject is described very adequately in elementary surgical text-books, it will not here be necessary to do more than remind the reader of certain fundamental principles, and to deal with those aspects of pathology and treatment which are properly discussed in an advanced text-book.

A *contusion* of an artery is of little consequence in the absence of arterial disease, as a healthy elastic vessel will slip out of the way, or simply alter its shape before a causative violence. An artery which is the seat of thrombo-angeitis or arteriosclerosis, however, is likely to be damaged, with the result that a *thrombosis* is initiated; even slight injuries may have this effect on a severely diseased vessel.

A *clean-cut transverse wound* of an artery of some size is associated with alarming hæmorrhage (fig. 2195). The bleeding is often worse if such a wound is *incomplete*, since the retraction of the elastic tissue and the contraction of the arterial muscle pull the wound open. With a *complete* transverse division the intima and media are at least able to contract and retract within the adventitia, and by markedly narrowing the lumen and providing rough surfaces give a chance for clotting to occur. In smaller arteries this natural process may result in early

arrest of the hæmorrhage, but in larger vessels the force of the arterial stream is too great to be stopped by it. When an artery is divided near its origin from a larger trunk, it bleeds with the force of the blood-pressure in the main vessel.

A wound in the *long axis* of an artery gapes but little and only slight bleeding may occur. The result of a *punctured wound* of an artery depends on the nature of the penetrating body. A stab wound, e.g. with a penknife or a glass splinter, causes extravasation and an arterial hæmatoma, with or without external evidence of bleeding; the skin

Fig. 2195.—Transverse incised wound of femoral artery. (*Museum, Royal College of Surgeons.*)

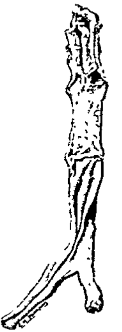


Fig. 2196.—Subadventitial rupture of artery. (*Museum, St. Mary's Hospital.*)

wound may be valvular, or become closed by clot or by shifting of tissue planes. If hæmorrhage ceases, the arterial wound may heal and the integrity of the artery be restored, but the scar is likely to yield later and produce a traumatic aneurysm. The same kind of thing may happen when an artery is injured by a modern bullet or by shell fragments, the resulting aneurysm being frequently of the traumatic arterial or arterio-venous type.

A *lacerated rupture* of an artery, such as occurs in a severe lacerated wound, or when a portion of the vessel is torn off, or the limb is avulsed, may be associated with comparatively little bleeding, even when the artery is of some size. The reason for this is that the intima and media

tear at a higher level than the adventitia, retracting some distance, and that the periarterial tissues close up over them. An intense reflex vasoconstriction also occurs in the torn artery, and chemical bodies are set free which favour clotting. These factors constitute a very efficient hæmostatic mechanism. Thus, the writer has seen the common femoral torn across in a boy who was impaled on some railings, with negligible bleeding, and with such marked retraction of the ends that they were well over an inch apart.

A *subcutaneous rupture* of an artery is caused by blows, severe traction, or by an injury causing a fracture or dislocation. Only the intima and media may give way, retracting within the adventitia for a considerable distance (fig. 2196); such a *partial rupture* will be followed by thrombosis and occlusion of the vessel. When only one side of the arterial wall is injured, the thrombosis may be limited to the injured part, and the lumen reconstituted by a growth of endothelium over the organised thrombus; this type of injury is likely to be followed by a traumatic, sacculated or dissecting aneurysm. A *complete* subcutaneous rupture of an artery of some size is always followed by extravasation of blood. When this rupture occurs within a body cavity, such as the pleura, peritoneum, or a hollow viscus, *concealed* or *internal hæmorrhage* occurs and may prove fatal. Rupture of more superficial arteries leads to the formation of an *arterial hæmatoma*, which is a rapidly enlarging swelling on the line of an artery, and showing an expansile pulsation. Such a hæmatoma soon compresses the neighbouring veins and the collateral arteries, thus endangering the vitality of the tissues of the part, and perhaps terminating in *gangrene*. The hæmatoma may *rupture* or *suppurate*, in either case possibly leading to a fatal result; not infrequently it becomes circumscribed, and if the artery is not completely occluded, a *traumatic aneurysm* may be the outcome.

Treatment.

The first step in the treatment of a wounded or ruptured artery is *temporary arrest of hæmorrhage*. The general principles may be summarised here: *Direct digital pressure* is applied to the source of bleeding, while the surgeon decides what method to employ for the temporary proximal compression of the artery. In the head and neck, and in the more proximal parts of the limbs (axilla and groin), the best procedure is manual or digital compression of the arterial trunk against a bony structure, e.g. the sixth cervical transverse process for the carotid, the first rib for the subclavian, etc. This *proximal compression* is given over to an assistant, while the surgeon prepares to deal with the arterial injury

itself. In the free parts of the limbs the simplest and most efficient agent of temporary arrest is a *tourniquet*, but it is very important that this should not be kept on for more than a very short period (half an hour at most), unless amputation is unavoidable; if continued for longer periods it may cause serious damage by shutting off collateral vessels, with an increased risk of gangrene when a main artery has to be ligated.

In the actual *treatment of the arterial wound* the first step is exposure of the wounded vessel. An adequate and well-planned incision, a sound knowledge of anatomy, efficient lighting, absolute asepsis, and a non-mutilating approach are essential. With a subcutaneous rupture all clots must be turned out and the region thoroughly cleansed before the arterial wound is sought for; in an open or penetrating wound there may also be a considerable extravasation into the tissues, which will have to be dealt with in the same way.

The second step is permanent arrest of hæmorrhage and treatment of the wounded artery. For this purpose two procedures are available, arterial suture and ligature. *Arterial suture* is, of course, the ideal procedure, and should be employed, whenever possible, in wounding of a large or important artery, such as the common carotid, external iliac, femoral or popliteal. Modern methods have made suture a practical and frequently successful operation. It is particularly suitable for longitudinal and transverse wounds which do not completely divide the artery (lateral suture), but under favourable conditions can also be employed for a complete rupture or division of a large artery (*end-to-end anastomosis*). The technique of arterial suture is given in a later part of this section (see page 4083).

Although an ideal procedure, arterial suture can only be undertaken by an expert surgeon, and is only applicable in special cases. The large majority of arterial wounds and ruptures have still to be treated by *ligature*. This is definitely indicated in injuries of smaller and relatively unimportant vessels, and will have to be resorted to in large arteries when suture cannot be effected, or when this fails. Ligature must be performed at the actual site of the arterial injury; proximal ligation often fails to arrest bleeding, owing to the presence of collateral branches between the ligature and the wound. When an artery is not completely divided, the vessel must be ligated above and below the injured segment, and the division completed by the surgeon, so that the two ends can retract. In a complete division or rupture, *both ends* must be found and ligatured, as serious *hæmorrhage* may occur from the distal end when the collateral circulation becomes established. The upper end of the

artery is found with little difficulty, its pulsations acting as a guide, but the distal end may need a good deal of searching for. Having dealt with the injured artery, the surgeon should carefully search for injuries of other vessels, or of neighbouring structures, such as nerves and tendons. After ligature of an important vessel a careful watch must be kept on the circulation in the tissues it supplies, and every possible care taken to avoid such complications as ischæmic myositis, gangrene, and secondary hæmorrhage.

For details and technique of arterial ligature the reader is referred to page 4085.

Arterial Thrombosis

Thrombosis rarely occurs in a healthy and uninjured artery. Attention has recently been drawn to the occurrence of a cyclic thrombosis in apparently quite healthy arteries and veins, which is due to an unexplained periodic increase of the coagulability of the plasma. The disease has been called *essential thrombophilia,* but so far as we know at present it is extremely rare.

Ordinarily, thrombosis in an artery is either primary or secondary. *Secondary thrombosis* occurs in a vessel already occluded by an embolus, which is usually a piece of blood clot brought from a more proximal part of the circulation ; the occluded vessel may or may not be diseased, but the thrombosis occurring locally is merely a process of clotting spreading from the embolus. Such thrombosis may extend both proximally and distally, and may involve collateral branches of the occluded artery. *Primary thrombosis* is essentially caused by *injury* or *disease* of the *intima* of an artery which has implicated the endothelial layer. Arterial occlusion, whether by ligature, vasospasm or disease, will not of itself cause thrombosis, if the intimal endothelium remains intact. Injuries act by producing rupture of the intima, and thrombosis is likely to result whether such rupture be partial or complete. Arterial disease (arteritis, thrombo-angeitis, or arteriosclerosis) causes thrombosis by ulceration or roughening of the intima.

In the presence of intimal damage, thrombosis is further predisposed to by infection (local or general), by slowing of the blood stream, and by increased viscosity or coagulability of the blood. In the limbs, these predisposing and actual causes of thrombosis are usually supplied by local arterial disease, but thrombosis of other arteries is sometimes attributable to systemic causes, such as protein shock, acute infective diseases and polycythæmia.

Arterial thrombosis is an important factor in the ætiology of *necrosis* and *gangrene*. Extensive disease may be present in the arteries of an extremity without seriously impairing its vitality, but the occurrence of thrombosis, either in the main artery or in its branches, is a common cause of failure of the local circulation, which terminates in gangrene. It must be pointed out, however, that thrombosis in a main artery will not result in gangrene, if the collateral circulation is normal; but if the thrombosis spreads into the collateral channels, or if these are obstructed by spasm or organic disease, then the vitality of the limb is immediately threatened.

The *diagnosis* and *treatment* of arterial thrombosis will be sufficiently dealt with in the articles on thrombo-angeitis (see page 4037), arteriosclerosis (see page 4043), and embolism (see below).

Arterial Embolism

The increasing success of the operation of embolectomy, which was first tried quite early in this century, has had the result of placing arterial embolism in the forefront of emergency surgery. The dramatic nature of its onset, the seriousness of its results, and the difference every hour makes to the success of surgical intervention, combine to invest the lesion with special interest to the adventurous mind of the modern surgeon. It is true that the opportunity to perform an embolectomy does not often come one's way, but it seems likely that more chances will occur when we convince physicians and general practitioners of the importance of timely diagnosis, and of the benefits of early operation.

Pulmonary embolism is not included in this article, as it has already received attention (see Vol. II, page 2165).

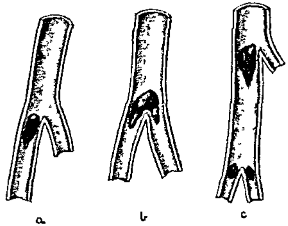
Pathology.

An embolus which lodges in an artery comes from the left side of the *heart* in more than 60 per cent of cases. Mostly it is a piece of organised blood clot detached from a diseased mitral valve, less often from a collection of ante-mortem clot in the left auricle. The heart may be the seat of malignant endocarditis, or of a simple endocarditis; auricular fibrillation not infrequently precedes the detachment of emboli. Occasionally the emboli come from septic foci in the lung, or from clot adhering to atheromatous ulcers in the aorta. In the rare cases of patent foramen ovale the emboli may be derived from the right side of the heart, or even from the systemic veins. Whatever their origin,

emboli are often multiple. A few months ago the writer saw a woman with embolism of the main arteries of all four limbs, with spontaneous recovery in one arm, Volkmann's ischæmic contracture in the other, and gangrene of both legs; the source of the emboli was a malignant endocarditis with marked fibrillation.

An embolus is carried by the blood stream until it reaches an arterial segment narrow enough to arrest its course. This site is usually one where a large or largish artery suddenly diminishes in size, and is frequently at or near a bifurcation; in the latter instance the embolus may not be quite large enough to obstruct the artery at once, but it may be arrested by saddling over the bifurcation, and subsequently completely block the artery by accretion of thrombosis. The most common sites of arrest, apart from the pulmonary artery, are the bifurcation of the common femoral, where the femoral pierces the adductor magnus, the

Fig 2197.—Mechanisms of embolic arrest.



bifurcation of the popliteal, and the bifurcation of the external iliac, the axillary artery where the subscapular branch is given off, and the bifurcation of the brachial. It must be noted that an embolus need not block an artery completely to cause total occlusion; the irritation produced by its presence excites a powerful vasoconstrictor reaction which converts a partial into a complete block for a sufficient period to enable secondary thrombosis to make it permanent.

The importance of *secondary* or *propagating thrombosis* following embolism is obvious. An embolus is associated with a much higher incidence of gangrene than a ligature of the vessel at the same point. In part this may be explained by coincident disease of the arterial tree, or by a depressed condition of the circulation as a whole, but unquestionably the chief reason is a peripheral spread of thrombosis down the artery and its branches, and particularly along the collaterals. Such a propagating thrombosis may completely occlude the territory of even

the most richly anastomosing artery, and not infrequently occurs with astonishing rapidity. Thus, some years ago the writer was able to show that the real cause of intestinal gangrene in embolism of the mesenteric arteries was not the embolus itself, but a secondary thrombosis propagated from it, and spreading widely and rapidly into the collateral vessels of the mesenteric arcades, as far as the vasa recta themselves (fig. 2198). This rapid spread of secondary thrombosis constitutes perhaps the strongest argument for prompt surgical intervention if the effects of arterial embolism are to be aborted. Fortunately, there appears to be an interval of a few hours before secondary thrombosis starts. Another factor deleterious to local vitality is a reflex vasoconstriction of the collateral vessels produced by sympathetic irritation

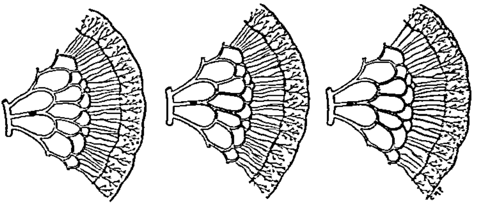


Fig. 2198.—Mesenteric embolism with propagating thrombosis.

of the arterial segment blocked by the embolus. According to Leriche this peripheral vasoconstriction seriously embarrasses the collateral circulation and may continue after embolectomy; to meet this danger, he suggests resection of the blocked segment of the artery (arteriectomy). This suggestion has recently been supported by Gosset, Bertrand and Patel.

Finally, it should be mentioned that small emboli may be detached from a main embolus in a proximal part of an artery, and move down to a lower level, or to one or more branches; such an occurrence may nullify the result of an embolectomy which removes the main embolus only. Furthermore, " showers " of minute emboli (e.g. from the lungs) may block a group of terminal vessels, and thus give a false clinical picture of main artery embolism.

Clinical Features.

It is important to remember that arterial embolism does not occur in a previously healthy patient. The majority are already suffering from obvious heart disease, many are seriously ill with malignant endocarditis, and some are in a state of auricular fibrillation. The discovery of a possible source for emboli is of great assistance in diagnosis.

The actual embolism is heralded by a sudden attack of very severe cramp-like *pain* in the affected limb. The pain is most marked along the course of the obstructed artery, but unfortunately it is always distal to the actual block, and is therefore not of much value in localising the exact site of embolism. The pain persists, although it may become less severe after a few hours. The pain is rapidly followed by *blanching*, most marked at the end of the limb, and increasing to a dead white pallor, and the patient may complain of *tingling* sensations. The pallid portion feels *cold* to the patient, and is actually cold to the touch. Quite soon *anæsthesia* occurs, producing a sensation of *numbness* to the patient, and this is accompanied by progressive *loss* of power, of muscular contraction, and of other functions. From the onset there is complete *loss of pulsation* in the arteries beyond the embolus, a sign of the greatest possible importance both in diagnosis and in localisation.

The *subsequent course* depends on the size of the vessel obstructed, and on the condition of the collateral vessels. The stage of intense pallor is usually followed by one of *patchy cyanosis*, which may or may not pass on to gangrene. *Gangrene* is much more likely to follow embolism of the lower limb than of the upper. With blockage of the brachial, and even of the axillary artery, there is more than a 50 per cent chance of recovery of the circulation without embolectomy; but, although gangrene may be averted, other ischæmic manifestations may result, such as permanent loss of power, wasting of muscles, and ischæmic contractures. In the lower limb, gangrene is extremely likely to result from embolism of the external iliac, common femoral, and upper part of the popliteal arteries, although the area which becomes gangrenous is usually considerably smaller than the total area supplied by the occluded artery. Embolism at the bifurcation of the popliteal artery or in the arteries of the leg is not likely to be followed by gangrene.

Diagnosis.

The diagnosis of arterial embolism is not difficult if its possibility is borne in mind. The sudden onset, the extremely severe and persistent pain, the loss of the pulse, followed rapidly by blanching, with sensations of tingling and numbness, constitute a very typical clinical picture, and when this occurs in a patient with a cardiac lesion,

especially a malignant endocarditis with fibrillation, there can be no room for doubt.

Many limbs can be saved by timely embolectomy, and an *early diagnosis* is therefore of the utmost importance. The brilliant results obtained by Swedish surgeons are largely due to the fact that physicians in that country are aware of the benefits of early operation, and are thus on the look-out for the occurrence of embolism. Similar results would be obtained in other countries if general practitioners were taught the importance of early diagnosis of embolism, and the benefits likely to be derived from timely surgical assistance. A good deal of suitable material might also be obtained if cardiac out-patients of hospitals were warned to report immediately symptoms and signs suggestive of embolism presented themselves.

Treatment.

The timely removal of an embolus from a large artery greatly increases the chance of survival of the limb, and therefore tends to prolong the life of the patient. It must be admitted that a large proportion of patients are already doomed by the concomitant cardiac lesion, but there is no reason why they should not be spared the horror of a gangrenous limb. Thus in 1933, Zierold published 11 cases of embolectomy, 9 of which were for lower limb emboli, with 8 recoveries of the circulation, but only 3 ultimate survivals of the patient.

Embolectomy was first successfully performed by Labey in 1911. In 1929, Key collected 216 cases, while in 1933, Danzis reviewed 129 cases in the literature between 1922 and 1932. All authorities agree on the importance of the *time factor.* Of 134 cases (reported by Key) in whom the operation was performed within 10 hours, 46 (34 per cent) were permanent cures, while 23 (17 per cent) died from the causative cardiac or vascular disease, but recovered their local circulation; this gives over 50 per cent of successful results from the embolectomy.

The earlier the operation, the better the outlook, for, with every hour that the embolus is left, progressive detrimental changes occur in the blocked part of the artery and in the vessels peripheral to it. Locally, the embolus becomes adherent to the arterial wall, in which degenerative processes and ulceration occur. The distal effects have already been mentioned, and are *vasoconstriction* and *propagating thrombosis.* The ideal time for operation is within *two or three hours* after the embolism, but up to six hours the outlook is definitely hopeful, as there is a delay of a few hours between the embolism and the occurrence of secondary changes in the artery and its branches. After twelve hours the prognosis is definitely poor, and after twenty-four hours the

operation is hardly worth doing, and gangrene is often already present; it should be mentioned, however, that Zierold reports two cases of successful result after 36 and 72 hours respectively.

Embolectomy is indicated with particular force in lower limb embolism, and in embolism of large arteries. It is unnecessary in blockage below the bifurcation of the brachial and popliteal arteries. In such cases, as well as in cases of high embolism which arrive too late for operation, the treatment has to be expectant (see section on Degenerative Arteritis, page 4043).

Localisation.

Apart from the avoidance of delay, *accurate localisation* of the site of embolism is the most important pre-operative factor of success. In most cases the embolus can be localised by a careful clinical examination, provided the clinician has a good knowledge of anatomy. The site of the *first pain* and the *upper limit of pallor* are of indirect value, inasmuch as they indicate that the embolism is at a higher level, but as the actual distance between the embolus and the ischæmic area is variable (depending mainly on the efficiency of the collateral circulation), the information obtained by this means is not sufficiently accurate. Of greater localising value is the examination of the arteries themselves, and particularly of their *pulse.* In an artery which is accessible to the fingers, e.g. the common femoral, axillary or brachial, one may be able to determine the exact point at which the pulse ceases, and sometimes even to feel the actual embolus as a longitudinal cord with a non-expansile transmitted pulsation. In deeper and, therefore, non-accessible arteries, information can still be obtained by examining the pulses, but it is less direct. Thus, if the pulse can be felt in the common femoral in Scarpa's triangle, but is absent in the popliteal, the probability is that the embolus blocks the bifurcation of the femoral.

When doubt still exists after a thorough clinical examination, localisation can be obtained by *arteriography*, but if this is not available the operation will be *exploratory* in the first place. The artery is exposed where there is most likelihood of the embolus being present; but if no embolus is found and the artery pulsates, a second incision is made lower down; when the artery does not pulsate and is empty, the second incision is made more proximally.

Arteriography.

By injecting a radio-opaque substance into an artery, it is possible by means of X-ray examination to localise an embolus with certainty. Arteriography has been employed in the investigation of cases of

arteriosclerosis, thrombo-angeitis, aneurysm, and arterio-venous fistula; it has also proved of some value in determining the condition of the collateral circulation in threatened gangrene from vascular disease.

The choice of a suitable and harmless radio-opaque solution has been a matter of considerable concern. Satisfactory visualisation of the arteries was first obtained by arterial injections of *sodium iodide* and *iodised oils*. Sodium iodide has proved too dangerous, as it damages the vessel wall and may cause gangrene: moreover it is painful and has been known to result in fatal poisoning. In 1930, Saito published 130 cases of successful injections with iodised oil, but this method is also dangerous owing to the possibility of oil embolism. The preparation in widest use to-day is *thorotrast*, a stable solution of *thorium dioxide*. It is injected on the X-ray table through an ordinary vein-puncture needle, under local anæsthesia; the artery proximal to the puncture is obliterated with a blood-pressure cuff, or the finger, as soon as it is certain that the needle is in the vessel, and 15 to 25 cc. of the solution injected. The skiagram is taken after three seconds, by which time the solution is distributed throughout the territory of the injected artery. In 1935, Veal and McFetridge reported on the results obtained by thorotrast injections in 200 cases; they claim that the solution is both painless and harmless, and that very valuable information can be obtained in cases of both threatened and actual gangrene, particularly in determining the best level for amputation. Thorotrast has also been widely employed in France, and in 1935 Leriche reported most favourably on it after extensive experience. The only drawback is that thorotrast is a mildly radio-active substance, and that it remains fixed in the tissues. Thus far no harmful consequences appear to have resulted, but the future will decide if any delayed effects occur.

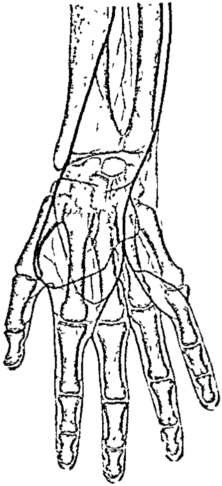


Fig. 2199.—Normal arteriogram.
(After Allen and Camp.)

Technique of Embolectomy (figs. 2200, 2201 and 2202).

Owing to the diseased condition of the cardio-vascular system, general anæsthesia must be avoided. *Local anæsthesia* should be preferred to spinal as the patient's sensations help in assessing the result of the operation. The blocked artery is exposed by a free incision, when it will be noticed that above the embolus the vessel is round and distended, with an expansile pulsation, while just below this part the firm mass of the embolus can be felt with ease. The wound is now flushed with sodium citrate solution, which is also used to moisten all instruments and swabs, and the adventitia round the blocked part of the

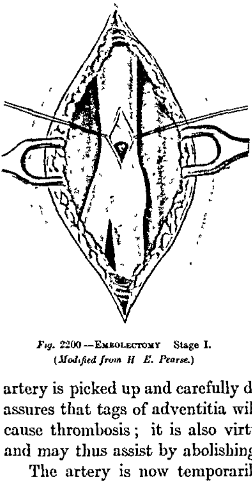


Fig. 2200.—Embolectomy. Stage I.
(*Modified from H. E. Pearse.*)

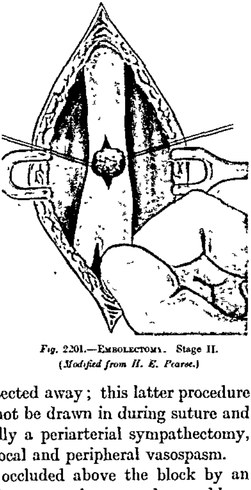


Fig. 2201.—Embolectomy. Stage II.
(*Modified from H. E. Pearse.*)

artery is picked up and carefully dissected away; this latter procedure assures that tags of adventitia will not be drawn in during suture and cause thrombosis; it is also virtually a periarterial sympathectomy, and may thus assist by abolishing local and peripheral vasospasm.

The artery is now temporarily occluded above the block by an assistant's fingers, or with non-crushing artery clamps, and opened by a longitudinal incision, preferably a little proximal to the clot. The embolus is then persuaded to extrude by gentle compression with the fingers, the artery being held open with fine traction sutures passed through its outer coats only. As soon as the block is removed some bleeding should occur from the distal end of the artery; if this does not

happen, then there are thrombi lower down, perhaps produced by propagating thrombosis. Such thrombi may occasionally be teased out with forceps, or removed by making a second incision in the artery some distance distally and irrigating the artery with citrate solution (fig. 2203).

As soon as blood starts to flow from the lower end of the artery, this is controlled by pressure or a clamp and the artery released proximal to the incision, and allowed to bleed for a moment, to wash out any proximal clot. The bleeding is then arrested again, and the artery and wound once more irrigated with citrate. The artery is now ready for suture, which is carried out along the lines indicated on page 4083.

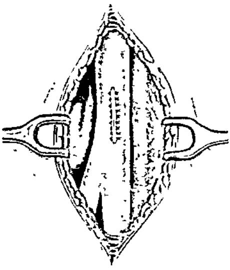


Fig. 2202—EMBOLECTOMY. Stage III. (*Modified from H. E. Pearse.*)

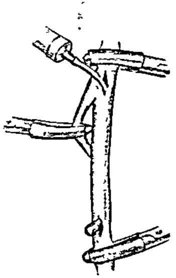


Fig. 2203.—PROCEDURE FOR REMOVAL OF DISTAL THROMBI.

If the exposed artery is empty, or completely solid with secondary thrombosis, whenever possible it should be exposed and opened by a second and more proximal incision. Where this cannot be done (e.g. the whole common femoral is empty or thrombosed), an attempt may be made to break up the embolus by passing a ureteric catheter up the artery, in the hope that a flow of blood will occur and wash it down. In embolism of the external or common iliac, the following procedure is sometimes successful: under spinal anæsthesia, the common femoral is opened below Poupart's ligament, while through an incision above the ligament the peritoneum is pushed out of the way, and the iliac vessel milked down in the hope of dislodging the clot.

Arteriectomy.

In 1933 Gosset and his associates, supported by Leriche, suggested that in certain cases extirpation of the thrombosed artery is

a more rational procedure than embolectomy. The advantages they allege are: (a) it is an easier operation, (b) there is no danger of damaging the intima and thus favouring subsequent thrombosis, and (c) it gives complete relief to the peripheral vasoconstriction, which is an important cause of inadequate collateral circulation. Other writers have recommended a *local arteriectomy*, limited to resection of the short segment of the artery in contact with the embolus, followed by end-to-end anastomosis (see page 4084). This has the advantage of removing the damaged part of the artery (where post-operative thrombosis is most likely to start), and at the same time of abolishing peripheral vasoconstriction, without depriving the limb of its main vessel or disturbing useful collateral arteries.

Vasospastic Diseases of Arteries

INTRODUCTION

In this section will be considered certain arterial conditions in which vasospasm plays a predominant part. The vasomotor control of blood-vessels is perhaps the main function of the sympathetic nervous system, although there is recent evidence that other factors enter into this control. Since the sympathetic system has been dealt with in a previous section of this work (see Vol. II, page 3099), it would be redundant here to embark upon a detailed discussion of the physiology of sympathetic activity, of methods of experimental and clinical investigation, or of the operations on the sympathetic devised to deal with vasospastic disorders. We shall, therefore, limit ourselves to a consideration of these disorders as *arterial* rather than as sympathetic lesions, and to a critical discussion of their surgical treatment, and of the results obtained therefrom.

The enormous interest attracted to the sympathetic system of recent years has somewhat obscured the fact that vasospastic disorders affect the arteries as well as their nerve supply. The experience of the past few years, however, is producing a more balanced outlook. Sympathectomy, even when wisely and widely performed, often gives only partial or temporarily complete relief, and sometimes leaves the patient no better, or perhaps even worse than before. For this and other reasons, attention is turning to other aspects of a problem which is proving more complicated than our early enthusiasm permitted us to think.

Of the essential nature of pathological vasospasm we know very

little. It can be produced by sympathetic stimulation of vasoconstrictor type; but it can also occur in a vessel which has been completely denervated, when it is either the result of a local tissue stimulus (e.g. cold), or of the action of " sympathomimetic " hormones reaching the arterial muscle via its blood supply. Why the abnormal sympathetic stimulation occurs, or why the local or blood-borne chemical stimulus takes place, is not clear. One thing, however, appears certain, and this is that vasospasm is not a separate entity, but occurs in numerous conditions, and is intimately associated with organic occlusive changes in the vessel walls. At present it would appear that the organic changes follow the functional spasm, and are caused by it, but the future may show that both are produced by the operation of a third factor, as yet unknown.

There are three common disorders of peripheral arteries, viz. degenerative diseases (arteriosclerosis, atheroma, etc.), thrombo-angeitis (Buerger's disease), and a large group of essential vasospastic conditions, of which Raynaud's disease is the most characteristic. At present we have no evidence that vasospasm plays any part in *arteriosclerosis* and allied forms of degenerative arthritis, but it is an important and possibly a causal factor in *Buerger's disease*, while in *Raynaud's* and similar disorders it is the predominant pathological event.

In this section will be considered only those conditions which are predominantly vasospastic. Raynaud's disease itself probably covers several distinct lesions, while allied to it are a number of more or less definite entities, such as *acrocyanosis*, *erythrocyanosis*, *hyperhydrosis*, and *erythromelalgia*. Vasospasm may also be a prominent feature in spinal cord lesions, especially *infantile paralysis*, in *cervical rib*, in *occlusion of large arteries*, and in *rheumatoid arthritis*.

A. Essential Arteriolar Vasospasm (Raynaud's Disease)

In the report of the Medical Research Council published in 1936 Lewis and Pickering, who have spent many years of study and research on disorders of the peripheral circulation, come to the conclusion that several distinct conditions are described under the heading of Raynaud's disease, and express the opinion that this term should be abandoned. Although we are bound to agree with this opinion, the name is too familiar to be dropped easily, but we propose to employ the alternative term " essential arteriolar vasospasm " and to limit it as far as possible to the class of case hitherto known as " typical " Raynaud's disease.

Pathology.

This condition is an *intermittent vasospasm* affecting the *digital arterioles* of the hands, and to a lesser extent the feet, without any occlusion of the larger arteries, and in its early stages without recognisable organic changes in, or permanent narrowing of, the peripheral vessels. The intensity of this *arteriolar spasm* was proved by Landis, who devised an ingenious method of measuring the capillary pressure in the nail-fold; writing in 1934, he states that under normal conditions the capillary pressure is about 40 mm., but during an attack of arteriolar spasm it may fall below 7 mm. As a result of this spasm certain colour changes occur in the fingers and toes, the physiology of which has recently been studied by Lewis and Landis. In the attacks of *blanching* (local syncope) the vasoconstriction is so intense that only a slight and intermittent leakage of blood occurs through the arterioles. During the earlier *cyanotic* attacks (local asphyxia) the spasm is less intense and more blood gets through the arterioles, while the actual colour (degree of cyanosis) depends on the stage of dissociation of oxyhæmoglobin into reduced hæmoglobin.

For a time Raynaud's disease apparently remains an *essential intermittent dysfunction*. But repeated attacks of arteriolar spasm in time lead to organic changes in the arterioles themselves, and also in the tissues they supply. The changes which occur in the digital arterioles are those of an *obliterating arteritis*. Cellular proliferation occurs in all the coats of the arterial wall, but particularly in the intima, and this is followed by fibrosis and structural occlusion. The picture is very similar to Buerger's disease, but only the smallest arteries and arterioles are affected. Until recently it was thought that these organic changes appear relatively late in the course of the disease, but we now know, on the authority of Lewis, that they often occur quite early. With the advent of structural changes Raynaud's disease passes from the stage of functional arteriolar spasm to that of organic occlusive arteritis. Although intermittent attacks of vasospasm still occur, subsequent vasodilatation becomes interfered with, and ultimately the vasodilator tests (see Vol. II, page 3172) may produce no appreciable increase of the blood-flow, showing that the arteriolar muscle has lost its ability to vasodilate. Among the structures affected at this stage are the *capillaries*. It has recently proved possible to microphotograph the capillaries of the nail-bed, using an oblique beam of light; in advanced Raynaud's disease they elongate, and become tortuous and dilated. The changes which occur in the skin and other tissues supplied by the vasospastic, and later fibrotic arterioles, are

given in the paragraph on complications; it may be stated at once, however, that the more serious and permanent changes, such as gangrene or scleroderma, are never the result of uncomplicated arteriolar spasm, but always depend on structural occlusion.

The actual *causation* of this condition of essential arteriolar vasospasm, or Raynaud's disease, is at present unsettled. Most writers still maintain that it is a *sympathetic neurosis*, resulting in abnormal activity of the vasoconstrictor nerves. This explanation was actually put forward by Raynaud as long ago as 1862, and there are several strong arguments in its favour. Among these are the high incidence of the disease in highly strung young women, the initiation of the attacks by emotional disturbance as well as by cold, the associated sudomotor activity, and the frequent, if temporary, relief of uncomplicated vasospasm given by sufficiently extensive sympathectomy. On the other hand, the failure to discover morbid changes in the sympathetic ganglia and other nerve centres leaves us without explanation of the origin of these vasoconstrictor impulses. Moreover, if the intermittent vasospasm is of nervous origin, why should it not involve other peripheral arteries or arterioles of the affected limbs?

In the last few years another view of the essential pathology of arteriolar vasospasm has been gaining ground. In 1929 Sir Thomas Lewis promulgated the theory that Raynaud's disease and allied forms of vasospasm are not due to disturbances of the sympathetic vasomotor control of vessels, *but to an increased susceptibility of the arteriolar* muscle itself to local stimuli, such as cold. This view is based on the experimental fact that strictly local vasospastic phenomena can be produced by local cooling and that these phenomena can be evoked after novocaine nerve block, and in sympathectomised patients. While this view and these findings have been questioned by J. C. White and others, there can be no doubt whatever that vascular tone and arteriolar spasm will return after a sympathectomy which has resulted in complete denervation of the vessels, and that such vascular tone and constrictor ability must be an essential property of the arteriolar muscle. In 1934 Smithwick, Freeman and White claimed that vasospasm after sympathectomy can be accounted for by the sensitivity of denervated arteriolar muscle to adrenalin, and that this sensitivity depends on degeneration of post-ganglionic sympathetic fibres. According to White, the reason for the much greater incidence of residual vasospasm after cervico-dorsal ganglionectomy, as compared with lumbar sympathectomy, is that in the former the degeneration of post-ganglionic fibres is almost complete, while in the latter sufficient remain

to protect the arteriolar muscle against the effect of circulating adrenalin. But more recently (1936) Grant has shown that the chemical substance is not necessarily adrenalin, but may be an adrenalin-like body, and that this does not come from the suprarenals or from the pituitary.

It seems reasonable to conclude that there are elements of truth in both hypotheses, and that the arteriolar muscle can be activated by sympathetic impulses, but also by chemical hormones in the circulating blood, or by chemical or physical changes excited and produced locally. Cannon has already shown that even the sympathetic does not act directly on plain muscle, but only through the intermediation of a chemical hormone, which he has called Sympathin E; this is said to be liberated between the nerve-endings and the arteriolar muscle as a result of vasoconstrictor impulses along the sympathetic nerves. Similarly, chemical bodies such as histamine, acetyl-choline, and a hormone christened the "H" substance, are now known to be responsible for vasodilatation. Adrenalin has long been known as an important vasoconstrictor hormone which circulates in the blood, but there is no reason why it should be the only one. In fact there is foundation for the belief that the adrenalin-like body recently described by Grant helps to maintain normal vascular tone, and that its concentration in the blood stream *may be a determining factor in the causation of excessive arteriolar constriction.*

By way of summarising these confusing facts, actual as well as hypothetical, the following theory is submitted of the pathogenesis of essential vasospasm. Normally, the tone of the arteriolar muscle, which is the controlling factor of vascular tone in general, depends on the action of chemical hormones, which are either brought to it via its blood supply, or manufactured locally. The degree of arteriolar tone is governed by the chemical nature of these hormones and by their degree of concentration. The circulating hormones may be of endocrine, myogenic or even neurogenic origin, while the local hormones are set free by sympathetic nerve impulses, or by local tissue changes excited by trauma, local cooling, etc. Some of these hormones are vasoconstrictor in action, others produce vasodilatation, and by balanced activity they are responsible for the maintenance of general vascular tone and of normal vascular reactions, for the conservation and loss of bodily heat, and for the adequate protection and blood supply of local tissues. We suggest that the essential cause of pathological vasospasm lies in an *inherent unbalanced sensitivity of the plain muscle of certain arterioles* to vasoconstrictor hormones, or alternatively that there is an inherent

tendency to the over-production of such hormones. We prefer the former explanation as it corresponds with the *local* distribution of pathological vasoconstriction. Admitting this arteriolar sensitivity, it is easy to see that attacks of pathological vasospasm may be excited by any factor which increases the supply of vasoconstrictor hormones. This factor may be a stimulus along the vasoconstrictor sympathetic nerves; it may be an increased concentration of adrenal, or pituitary, or other constrictor hormones in the blood; or it may be a strictly local accumulation of chemical hormones, produced by the action of cold or some other local stimulus. In normal people the increased production or supply of these vasoconstrictor hormones produces normal vasoconstriction, while in people with abnormally sensitive arteriolar muscle it causes pathological vasospasm.

This theory is submitted for what it is worth. At least it bridges over the main differences between the "sympathetic" and "local" schools, without conflicting with either. The removal of one source of supply of constrictor hormones (e.g. by sympathectomy) may abolish pathological vasospasm when the sensitivity of arteriolar muscle is only moderately increased; it may produce a temporary improvement even when the arteriolar sensitivity is markedly increased; but it cannot be expected to result in permanent cure, or even constant improvement, as the arteriolar sensitivity remains untouched, and the remaining sources of supply of vasoconstrictor hormones may soon compensate for the loss of one of them. We are thus able to account for the inconstant results of surgical denervation of the spastic arteries, and to harmonise the early improvement and subsequent relapse which are so commonly experienced after cervico-dorsal sympathectomies for Raynaud's disease. The higher incidence of prolonged relief after lumbar sympathectomy for vasospasm of the lower limbs may after all not be due to intact post-ganglionic neurones, but to a naturally lower level of increased sensitivity of the arteriolar muscle in this region, than in the more specialised and exposed extremities of the upper limbs.

Clinical Features and Course.

A mild tendency to arteriolar spasm is extremely common and is responsible for the "chilly" manifestations of otherwise healthy people who are said to have a "poor circulation." Their fingers become white or blue in cold weather, or after a few minutes in the sea, they are always warming their hands before the fire, and they are inordinately fond of hot-water bottles, bed-socks and thick gloves. Most of these people are women, and they are usually young and "highly strung." The phenomena they present are only an exaggeration of the normal vasocon-

strictor response to a cold stimulus, which is always most intense in the extremities. The attacks of vasoconstriction can be set into operation by stimuli other than cold, e.g. fear or intense emotion. Most of these "chilly" people lose their tendency to arteriolar spasm with the advent of middle age, but some show a progressive increase of vasoconstrictor tendencies, and in time become typical examples of Raynaud's disease. Considerable emphasis is laid by White on this sequence of events, and he states that the change over from the prodromal "chilly syndrome" to the fully fledged stage of Raynaud's disease sometimes follows intense emotional strain. Raynaud's disease may start at puberty, but is most commonly seen in the twenties. The worst cases begin young, while milder cases may not emerge from the prodromal stage until after thirty. More than nine-tenths of the cases are women, most of them of a neurotic or emotional disposition. Arteriolar spasm sometimes runs in families.

A typical established case complains of *intermittent attacks* of *symmetrical vasospasm* in the hands, and to a lesser extent the feet, with marked reduction of blood-flow in the digits. The attacks are brought on by cold, and occasionally by emotional disturbance. The arteriolar response to cold occurs below a certain *threshold of temperature*, which varies with the intensity of the disease, but is usually round about 60 degrees. At first, the attacks subside rapidly when the environmental temperature is raised above the critical threshold, e.g. going into a warm room or immersing the hands in warm water; but at a more advanced stage the vasodilator response is much slower, and may be incomplete.

The attack of arteriolar spasm is manifested clinically by sensations of *numbness*, followed by *tingling*, and by symmetrical *colour changes*, which are typically *phasic*. In a mild case the colour change may be limited to a *cyanosis* (local asphyxia), varying in tint from grey to purple, mostly affecting the fingers, and fading up the palm; similar changes affect the toes, but are characteristically milder. In advanced cases the colour changes are more definitely phasic, and the cyanosis is either preceded or followed by attacks of *blanching* (local syncope). This starts at the tips of the fingers, and spreads to their whole length, but does not involve the hand and is rarely seen in the toes; the colour reached at the height of the attack is dead white. It is probable that by the time attacks of complete local syncope occur there is some degree of structural occlusion. The *pulse is unaffected*, even in peripheral arteries such as the radial at the wrist, and the anterior and posterior tibial at the ankle. *Sweating* is a common and troublesome

symptom which may accompany the vasospastic attacks, but can also occur without them, and may even precede them for months. Particularly annoying are "attacks" of profuse hyperhydrosis brought on by emotion or excitement in young people, but these probably represent a clinical entity which is distinct from essential arteriolar spasm (see page 4036).

Further Course and Complications.

In mild cases the disease may show a spontaneous improvement with increasing age, or it may be cured by treatment or by removal to a warmer climate. But in more established cases the vasospastic attacks become more frequent and severe, occur at higher temperatures, and cause considerable disability, especially in cold weather. Moreover, further changes occur which might be classed as *complications*. Arteriolar spasm may affect the *nose*, *ears*, and even the *tongue*, while renal vasospasm occasionally occurs and causes an *intermittent hæmoglobinuria*. Vasoconstriction of the *retinal arteries* causes attacks of blurring of vision, while spasm of *cortical arteries* is occasionally responsible for transient hemiplegia or aphasia. Perhaps the most interesting complications are those which affect the *skin* of the digits. After repeated attacks of local syncope, patches of *anæmic ulceration* appear at the finger-tips. They heal in warm weather, but repeatedly break down, and after a while result in *dry gangrene*; this is usually quite superficial, but occasionally extends as far as the bone. By this time the disease is well past the stage of uncomplicated arteriolar vasospasm, and considerable structural changes are present in the arterial walls. In some cases the skin atrophies and becomes shiny, while the nails may show various degrees of *onychia*. At this stage the fingers become very susceptible to infection, and *paronychial whitlows* are common. In another and particularly severe type of the disease marked subcutaneous fibrosis occurs, with hardening and fixation of the skin to the underlying fascia (*scleroderma* and *sclerodactyly*).

Interesting changes also occur in the *bones* in chronic cases. The usual change is *decalcification* of the terminal phalanges, probably caused by reactionary hyperæmia following the syncopal attacks. In 1934, Watson Jones and Roberts drew attention to nodules of *calcification* which sometimes develop in and under the skin of the terminal phalanges and more proximally. They are mostly seen in conjunction with atrophic skin changes, and are doubtless caused by prolonged deficiency of the local blood supply owing to occlusive arteritis. It must be observed that there are reasons for believing that some of the above conditions are not actually stages in essential arteriolar

vasospasm (or "typical" Raynaud's disease), but represent allied vasospastic lesions as yet imperfectly differentiated from the main group.

Differential Diagnosis.

Apart from some of the complications, the above description applies to typical cases of Raynaud's disease. Many cases are encountered, however, which are *atypical*. The writer has seen a case in which vasospastic attacks with phasic colour changes occurred mostly on warm days, and another in which vasospasm was much more marked in the toes than in the fingers (this was not a case of thrombo-angeitis). Then there are patients who instead of having intermittent attacks suffer from more or less continuous vasospasm, while in others the arterial spasm is caused by some extra-vascular organic lesion, such as cervical rib, infantile paralysis, or rheumatoid arthritis. Although such cases differ from true Raynaud's disease, they resemble each other in so far as their circulatory disturbance is due to vasospasm. Of greater importance in the differential diagnosis are circulatory lesions caused by *organic arterial occlusion*. There are cases of arteriosclerosis and thrombo-angeitis which in some respects imitate Raynaud's disease, even to the extent of showing symmetrical colour changes in the hands and feet. The imitation, however, is never complete, and it is nearly always possible to discriminate between them. Organic arterial disease shows a different age and sex incidence; vasospastic phenomena, when they occur, are more rapid in their onset and do not last long; the peripheral pulse is weak or absent, or the arteries are obviously sclerosed, and calcification may be shown in skiagrams; muscular pain and actual claudication may occur. Any doubt left will usually be dispelled by the various vasodilator tests, although some difficulty may even then be found in distinguishing Buerger's disease or arteriosclerosis from late cases of vasospasm, with organic arterial changes.

Treatment.

The treatment of Raynaud's disease has always been unsatisfactory, and the surgical intervention so energetically pursued in the last five or six years has not done very much to improve it. Owing to the comparative failure of medical treatment, however, operative measures are justified if something more than transient relief can be expected of them, and if the course of the disease renders an attempt to arrest it desirable, even if such arrest proves partial.

Medical Treatment. The only really successful remedy is a change to a *warmer climate*, at least during the winter months. This will cure the

mild cases of intermittent spasm, with a low critical temperature threshold, whose circulation recovers completely between the attacks. For obvious reasons, this measure is only possible to wealthy patients, or to those who can find work in warm countries. Moreover, it will give only partial relief to more severe cases, with a high temperature threshold, and with commencing organic occlusion. Warm covering for the hands and feet in cold weather, and avoidance of unnecessary exposure and of emotional disturbances, are prophylactic measures suggested by common sense.

Physiotherapy, in the form of massage, radiant heat and diathermy, is of transient benefit, while *endocrine therapy*, and *X-ray treatment* to the sympathetic ganglia have been tried without much success. *Vasodilator drugs*, such as padutin and carnacton, are of little value in an intermittent condition. Definite temporary improvement, on the other hand, has been obtained with *fever therapy* (e.g. mixed typhoid vaccine at weekly intervals), with *dinitrophenol*, and with *typhoid H antigen*, all of which produce a marked dilatation of the arterioles, sufficiently prolonged to heal digital ulcers; but the first two are dangerous and unpleasant, and they all give only a short period of relief.

Operative Treatment. Before deciding whether or not to adopt operative treatment, several points must be given careful consideration: (1) Are the symptoms, or the degree of disability, sufficiently severe to justify an operation? (2) Is the disease progressive or stationary, or are there signs of improvement? (3) Do the vasodilator tests (see Vol. II, page 3173) indicate that the disorder is in the stage of functional arteriolar spasm, or do they show that organic occlusive changes are already present? (4) What exactly do we hope to obtain as the result of surgical intervention? (5) To what risk, if any, is the patient subjected by the operation?

We are certainly in a stronger position to-day than we were five years ago, inasmuch as the intensive surgical attack indulged in during this period has led to the accumulation of valuable knowledge based on experience. This knowledge enables us to select the cases most suitable for operation, to plan our operative procedures so as to give them the optimum chance of success, and to forecast the immediate and ultimate results which are likely to follow. In general, it may be stated that *operation is contra-indicated* in mild cases without serious disability, *and in cases which show a tendency to become stationary or to improve* spontaneously. Such patients should be kept under observation and be thoroughly re-examined every winter; vasodilator tests should be performed at regular intervals and complete records kept. In this way

we can determine whether the disease is improving, stationary, or progressive. Only when it is *progressive* should operation be considered, but if performed at all, it should be done at a relatively early stage, and while the disease is still mainly a functional vasospasm. We must also be quite certain that a *correct diagnosis* has been made, and that such conditions as cervical rib, myxœdema, thrombo-angeitis and arteriosclerosis, have been definitely excluded.

We thus arrive at the conclusion that operation should be considered in proved cases of uncomplicated arteriolar spasm in whom the disease is definitely progressive. The position is more difficult with regard to more advanced cases with commencing organic arteritis. Here the operation has a smaller chance of success; on the other hand, the disease is more troublesome, the disability greater, and the need for some relief more urgent. Our decision must be guided by the extent of disability present, and by the degree of vasodilatation which is still possible. When the vasodilator tests have shown that the vessels have lost their power to dilate, operation is obviously useless, but when *they still retain a reasonable proportion of their vasodilator power it* may yield real benefit, even if this be only in the direction of ameliorating complications.

The choice of *operative procedure* rests between periarterial sympathectomy, ramisectomy, and ganglionectomy. *Periarterial sympathectomy*, although still advocated by Leriche, has been largely abandoned. It is a very simple and harmless operation, but is only occasionally successful, and *then it gives only partial and temporary relief. Why it* yields even this transient benefit is a mystery, as the peripheral vasoconstrictor fibres travel along the somatic nerves and not along the main vessels. *Ramisectomy* was given a fair trial after the failure of periarterial sympathectomy. The operation consists of a division of the grey rami to the brachial plexus. Some successes followed its use, but these were usually either incomplete or temporary. The principles of ramisectomy are quite sound, but its technical difficulties are so great as to be almost insuperable. The rami are small, difficult to recognise, and have no constant plan in their arrangement; there may be several rami to each nerve and, unless every one is divided, partial failure is inevitable. Furthermore, the branch from the second thoracic ganglia to the brachial plexus was not known at the time that ramisectomy was in vogue. Even after a successful ramisection the vasospasm returns, usually after some months, probably owing to regeneration of the rami.

Cervico-dorsal ganglionectomy (see Vol. II, page 3190) is much the most

comfortable, and perhaps postpone organic changes and complications. On the other hand, in the more serious cases, in which the need for relief is greater, the ultimate result tends to be definitely unsatisfactory. The initial relief of spasm still occurs, and this may temporarily improve the patient's condition, and remedy troublesome complications, but eventual relapse is almost inevitable. Indeed, in some cases the patient's ultimate condition is worse than before the operation, chiefly because of the inability of the vessels to dilate when the environmental temperature is raised. Lewis and Pickering have proved the existence of vasodilator nerves in the sympathetic, by showing that sympathetic ganglionectomy destroys the power of peripheral arterioles to dilate as well as to vasoconstrict. It is undoubtedly this *loss of vasodilator reactions* that constitutes the chief drawback to sympathetic operations. Prior to operation the patient at least had the warm weather to look forward to, and could relieve vasospastic attacks by raising the environmental temperature; after it, even this temporary relief may be denied. We believe that serious consideration should be given to this possibility before operation is decided upon.

The remote results of *lumbar sympathectomy* for vasospasm of the lower limbs are much more satisfactory, and a large measure of prolonged relief may be confidently expected. Unfortunately, however, essential arteriolar spasm nearly always involves the upper limbs more than the lower, and it is small comfort to the patient to be cured of the lesser evil, while the greater ill remains unrelieved.

By way of conclusion, certain statistics may be quoted, which give an indication of the ultimate results of operation. In 1933, Gask reported seven cases of cervico-dorsal ganglionectomy for Raynaud's disease, most of which relapsed by the next winter. In 1935, White reported 26 cases of ganglionectomy for arteriolar spasm, many of them with complications suggesting organic changes. Twenty were cervico-dorsal sympathectomies, in ten of which the operation was thought to be incomplete, while six of them (60 per cent) resulted in failure. The other ten were complete resections of the stellate and second thoracic ganglia; in all the circulation of the hand, as shown by blood-flow measurements, remained poor; five were partial successes (50 per cent)

bright spot in the outlook of the surgery of vasospastic disorders. It should encourage further research until, as White states, a solution is found to our present difficulties with persistent vasospasm in the upper limbs.

B. Other Vasospastic Disorders

(1) *Acrocyanosis.*

This is a condition very closely allied to Raynaud's disease, and indeed generally regarded as a variety thereof. It is again an essential arteriolar spasm, and affects the most peripheral parts, especially the hands, nose and ears. Attacks of cyanosis occur in these exposed parts, but these attacks tend to be much more prolonged than in true Raynaud's disease; indeed, in some cases the hands are always cold and blue, except when the weather is very warm. With regard to *treatment*, there is nothing to add to what has been stated in the last section.

(2) *Erythrocyanosis.*

In a recent article (1936) Telford and Simmons give this abbreviated name to the condition hitherto called by the cumbersome title of *erythrocyanosis crurum puellarum frigidum.* It is a common disorder which affects young women and girls with stout and florid physique and large limbs, and consists of a reddish blue discolouration of the lower half of the calf. Males are very rarely affected.

Minor degrees of erythrocyanosis are extremely common but cause no disability. Occasionally, however, the disease becomes severe and may have very unpleasant consequences. In a typical advanced case, the lower half of the calf becomes purple and cold to the touch, while the circumference of the limb is increased by cellular infiltration of the subcutaneous tissue. The purple skin can be blanched by pressure, but the colour returns from all sides when the pressure is relaxed. The hair follicles shed their hair and enlarge, appearing as small red points on the purple skin. In some cases enormous hypertrophy of the subcutaneous tissue occurs, producing a thick cuff which projects just above the back of the ankle. The worst cases develop indurated nodules under the skin, which become painful and very tender, and may ulcerate; these ulcers may only heal in summer weather. Itching and burning sensations add to the patient's discomfort. The skin over the triceps may also be affected, but rarely to the same degree.

For some time the condition was thought to be tuberculous in origin, or to be an endocrine dysfunction, but there has never been any

comfortable, and perhaps postpone organic changes and complications. On the other hand, in the more serious cases, in which the need for relief is greater, the ultimate result tends to be definitely unsatisfactory. The initial relief of spasm still occurs, and this may temporarily improve the patient's condition, and remedy troublesome complications, but eventual relapse is almost inevitable. Indeed, in some cases the patient's ultimate condition is worse than before the operation, chiefly because of the inability of the vessels to dilate when the environmental temperature is raised. Lewis and Pickering have proved the existence of vasodilator nerves in the sympathetic, by showing that sympathetic ganglionectomy destroys the power of peripheral arterioles to dilate as well as to vasoconstrict. It is undoubtedly this *loss of vasodilator reactions* that constitutes the chief drawback to sympathetic operations. Prior to operation the patient at least had the warm weather to look forward to, and could relieve vasospastic attacks by raising the environmental temperature; after it, even this temporary relief may be denied. We believe that serious consideration should be given to this possibility before operation is decided upon.

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bright spot in the outlook of the surgery of vasospastic disorders. It should encourage further research until, as White states, a solution is found to our present difficulties with persistent vasospasm in the upper limbs.

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(2) *Erythrocyanosis.*

In a recent article (1936) Telford and Simmons give this abbreviated name to the condition hitherto called by the cumbersome title of *erythrocyanosis crurum puellarum frigidum.* It is a common disorder which affects young women and girls with stout and florid physique and large limbs, and consists of a reddish blue discolouration of the lower half of the calf. Males are very rarely affected.

Minor degrees of erythrocyanosis are extremely common but cause no disability. Occasionally, however, the disease becomes severe and may have very unpleasant consequences. In a typical advanced case, the lower half of the calf becomes purple and cold to the touch, while the circumference of the limb is increased by cellular infiltration of the subcutaneous tissue. The purple skin can be blanched by pressure, but the colour returns from all sides when the pressure is relaxed. The hair follicles shed their hair and enlarge, appearing as small red points on the purple skin. In some cases enormous hypertrophy of the subcutaneous tissue occurs, producing a thick cuff which projects just above the back of the ankle. The worst cases develop indurated nodules under the skin, which become painful and very tender, and may ulcerate; these ulcers may only heal in summer weather. Itching and burning sensations add to the patient's discomfort. The skin over the triceps may also be affected, but rarely to the same degree.

For some time the condition was thought to be tuberculous in origin, or to be an endocrine dysfunction, but there has never been any

evidence in favour of these views. Actually, it is very similar to the vascular lesions of severe infantile paralysis. The chief ætiological factor is undoubtedly a defective blood supply in a fatty area which is far out in the peripheral circulation. and which is exposed to the effect of cold owing to the feminine practice of leaving the lower limbs uncovered. There is probably a combination of arteriolar spasm with a deficient venous return, with the result that a harmful tissue product accumulates locally, which may be responsible for the reactive formation of nodules. Telford and Simmons suggest that the nodules of Bazin's disease, and of so-called traumatic fat necrosis, have a similar ætiology.

The *treatment* of mild cases consists mainly of warm covering and physiotherapy. For severe cases Telford and Simmons strongly recommend bilateral lumbar ganglionectomy. They publish ten cases, with excellent results from six months to four years after operation.

(3) *Hyperhydrosis.*

This is a distressing condition characterised by profuse sweating of the hands and feet, occurring in attacks. The patients are mostly young and highly strung individuals, and the attacks are generally brought on by emotional disturbances. Sympathetic dysfunction is undoubtedly responsible, and there may or may not be associated arteriolar spasm. The condition is an obvious handicap in certain occupations, as well as being a source of considerable worry and embarrassment.

Medical treatment is useless, and the only hope of cure lies in sympathetic denervation. This has been done both by ganglionectomy and by paravertebral alcohol injections into the sympathetic ganglia. The results of such operations have proved far more satisfactory than when performed for Raynaud's disease, as indeed would be expected from the unilateral sympathetic ætiology of hyperhydrosis.

(4) *Other Vasomotor Lesions.*

Sympathetic denervation has been tried in several conditions associated with disturbances of vasomotor control. Lumbar ganglionectomy has been performed for the chronic chilblains and cutaneous ulceration of the legs in *infantile paralysis, pyramidal tract lesions, spinal cord injuries*, etc.: the skin complications in these lesions are caused by defective blood supply with reduction of the arterial inflow and retardation of the venous return. There is also an associated vasoconstriction, as shown by the marked response to vasodilator tests. Such cases do extremely well after a lumbar ganglionectomy, although recurrence of the skin lesions ultimately occurs in a proportion of them.

Sympathectomy has also been performed on a large number of cases of *rheumatoid arthritis* with associated vasospasm. In selected cases, with a favourable vasomotor index (see Vol. II, page 3178), good results have been obtained; the circulation of the cold, clammy, and cyanotic limbs has been markedly improved, and some cases experienced considerable relief of pain, and even actual improvement of the arthritis.

Sympathetic surgery has also played a part in the treatment of *causalgia.* Since this condition is nearly always accompanied by marked vasomotor changes, it is safe to assume that there is coincident irritation of the sympathetic centres. Cases in which definite temporary relief is given by blocking the corresponding ganglia with novocaine should be treated by alcohol injection or ganglionectomy. Some success has also been claimed for periarterial sympathectomy.

Thrombo-angeitis Obliterans (Buerger's Disease)

It is curious that this important and far from rare disease escaped adequate recognition until Buerger gave it the above title and wrote a comprehensive monograph on it in 1924. He described it as a chronic occlusive disease of medium-sized arteries, especially in the lower limbs, almost limited to men, and showing a special predilection for Jews and for heavy cigarette smokers. Buerger also indicated that some cases show an associated thrombophlebitis, which may actually precede the occlusive arteritis. Since 1924 a great deal of work has been done on this disorder, and it is now recognised as a definite clinical and pathological entity, belonging to the vasospastic group of arterial diseases. Its outstanding features are severe claudication pain, colour changes, trophic troubles, and a marked tendency to gangrene.

Incidence.

The most striking feature of the disease is its limitation to men, who constitute 99 per cent of the victims. Although most patients are between 40 and 50 when they first come to us for treatment, they are usually by this time in an advanced stage of the disease, which probably starts in the middle thirties. Thrombo-angeitis affects the lower limbs and is nearly always bilateral, but the disease begins in one leg and then attacks the other; the upper limbs rarely share in the occlusive arteritis, although in some cases they show evidence of arteriolar spasm. The alleged preponderance of Jews has not been confirmed by

recent statistics, nor is there reliable evidence of other racial or class predilection, except that the disease often seems to attack men engaged in occupations involving exposure to inclement weather. Considerable difference of opinion has recently been expressed on the part played by *cigarette smoking*. The disease has been reported in non-smokers and it is very doubtful if tobacco ever acts as a direct cause. In a recent article (1935), however, Lampson has shown that during cigarette smoking there is a marked peripheral vasoconstriction, causing a fall in peripheral blood-flow and skin temperature, and an appreciable rise

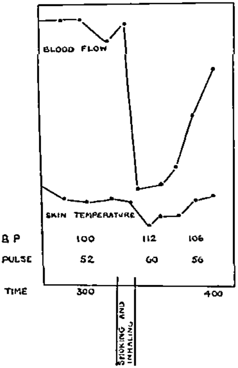

Fig. 2204.—Effect of cigarette smoking on peripheral circulation. (*After Lampson*)

of the blood-pressure and pulse (fig. 2204). This effect is increased by inhaling, and occurs both in normal people and in those with thrombo-angeitis, in whom it may cause sensations of coldness and pain. We conclude that inhaling cigarettes is an important contributory cause of thrombo-angeitis, and that it certainly does harm to patients already suffering from arterial disease.

Ætiology.

The actual causation of the disease is unknown. There is no evidence of blood changes, nor does syphilis or any other cause of arterial degeneration play any part. The one clear conclusion which emerges from recent research is that *arterial spasm* plays a definite part in ætiology.

It would appear that the disease starts as an intermittent vasospasm, that this spasm becomes more continuous, and that after a period, probably of some years, occlusive arteritis and thrombosis supervene. There are, therefore, broad similarities between thrombo-angeitis and Raynaud's disease, but the differences are even more striking, for while the latter attacks the upper limbs of young women, the former is almost limited to the lower limbs of middle-aged men. It almost seems as if there is some unknown factor which influences the effects of vasospasm according to the sex and the extremity involved. In this connection, it is of interest to observe that in the so-called epidemics of ergotism most of the patients are men and the lower limbs are more often affected. For the causation of the initial vasospasm there is no clear explanation. It is possible that continued exposure and tobacco may play some part, or that some cases may be toxic in origin, but it is more likely that these factors are predisposing rather than direct causes. There is certainly nothing to suggest sympathetic neurosis or excessive adrenal activity, and excised sympathetic ganglia show no pathological changes.

Morbid Anatomy.

Thrombo-angeitis mainly affects medium-sized arteries of the leg, e.g. anterior tibial, dorsalis pedis and posterior tibial. The disease attacks the arteries in a " patchy " manner, leaving lengths of normal vessel between the affected areas, but it nevertheless proceeds to complete arterial occlusion. The effects of such occlusion depend on the artery involved and on the condition of the collateral anastomotic channels. Serious results occur in occlusion of the upper part of the popliteal artery, where the anatomical provision for a collateral circulation is distinctly poor. The limb is also endangered by associated vasospasm of anastomotic branches, and later on by spread of the thrombotic process into the collateral vessels, or by a proximal extension into the femoral and iliac arteries. Fortunately, in most cases the disease remains localised to the medium-sized arteries, and the collaterals escape organic occlusion. Organic changes start in the *intima* which shows endothelial and sub-endothelial proliferation and becomes thickened and irregular. *Thrombosis* begins at the intimal irregularities; the clots are at first small and adherent to the arterial wall, but later the thrombosis spreads to uninvolved parts of the artery, where the clot lies free from the adjacent normal intima. The organic disease, therefore, starts as an obliterative endarteritis, the narrowed lumen becoming *completely occluded* by thrombosis. Later on, fibrosis occurs in the *media* and spreads through to the *adventitia*, and even to the perivascular tissues. By this time the thrombus has organised into

fibrous tissue, and it may show evidence of recanalisation. Although the disease is usually limited to the legs, occasionally it affects the upper limbs, and it has been reported in the coronary and mesenteric arteries.

The veins are affected in only a minority of cases, the condition being mainly a venous thrombosis with relatively little endophlebitis. Rarely, the *thrombophlebitis* precedes the arterial changes, and it is interesting to observe that it is sometimes of the *migrans* type.

Clinical Course.

The symptom that brings most patients to seek medical advice is *claudication*. This is a very intense cramping pain in the muscles of the calf and in the foot, which at first comes on after walking a considerable distance, and which is relieved by resting for a few minutes. Although the claudication starts in one leg, sooner or later it involves both. As the disease progresses, the pain comes on after walking shorter and shorter distances, and the patient is often pulled up quite suddenly by it. Walking rapidly or uphill brings on the claudication more quickly. Sooner or later, any muscular exercise causes pain and, worst of all, it begins to occur when the patient is at rest. This rest-pain is most severe in bed, but some relief is obtained by keeping the leg outside the bedclothes, and especially by hanging it over the edge of the bed.

On questioning the patient we may elicit the fact that attacks of coldness and blanching of the feet were noticed before the onset of claudication, and similar attacks may occur in the established stage of the disease. Occasionally these attacks are accompanied by sweating, and there can be no doubt that they are vasospastic in origin; they certainly support the view that thrombo-angeitis starts as a pure arterial spasm.

Some months or years after the onset of claudication, *postural colour changes* occur in the foot. At first the foot becomes discoloured only when it is hanging down; the colour is a dull red, starting in the toes and spreading up the dorsum. On elevation of the foot the red colour goes and gives place to a dead white blanching. The size of the angle of elevation required to produce blanching is known as the angle of circulatory efficiency, and is an index of the degree of arterial occlusion. The condition of the *pulse* in the palpable arteries is of great diagnostic importance. By the time claudication is well established, no pulsation can be felt in the dorsalis pedis or the posterior tibial, while in advanced cases the pulse is also lost or weakened in the popliteal and in the lower two-thirds of the femoral arteries. It is rarely lost in the femoral

artery above its bifurcation. In an excellent article published recently (1935), Telford and Stopford report cases in which the pulse in the tibial arteries was sometimes present and sometimes absent. The same phenomenon was observed in one case by the writer, and must be taken as strong evidence of intermittent arterial spasm. The thrombosed arteries can occasionally be felt as solid cords, largely owing to perivascular fibrosis.

Having reached this stage, the disease may remain stationary, and in some cases a *spontaneous improvement* sets in. This is partly attributable to opening up of collateral channels, but may be contributed to by recanalisation of the thrombosed arteries. In more than half the cases, however, the course unfortunately progresses downhill. *Trophic troubles* appear in the form of chronic onychia, with loss of nails, callous ulcers, and other skin changes. Finally, in about a quarter of the cases, black necrotic areas appear on the toes or heel, and spread more or less rapidly, usually as a *moist gangrene*, up the foot and leg. In the average case, several years elapse before this final stage is reached. Occasionally the course of the disease is *acute* and gangrene may come on in as little as three months. Telford and Stopford describe one case in which death occurred six months after the onset of claudication, from thrombosis spreading up the aorta and occluding the inferior mesenteric artery.

Thrombophlebitis appears in 10 to 15 per cent of cases, and is mostly of the migratory type (see page 4005).

Treatment.

Before undertaking treatment it is essential to exclude other types of arterial disease, particularly arteriosclerosis. The distinction from arteriosclerosis should not be difficult, as this affects people ten or more years older, is much more generalised in its distribution, and can be diagnosed by X-ray pictures. Having established the diagnosis of thromboangeitis, it is then wise to classify the case into one of two types—(1) with a good vasodilator response, and (2) with a poor vasodilator response. The simplest way of determining the *vasodilator power* of an ischæmic lower limb is with *spinal anæsthesia*. Cases associated with vasospasm, or in whom the collateral channels are capable of good vasodilatation, will respond well, showing a rise in their skin temperature of 10 to 15 degrees, as well as an improvement in colour and warmth. Such cases can be expected to derive real benefit from sympathetic denervation. When the vasodilator response is poor, however, it is obvious that little can be hoped for from operations on the sympathetic.

Medical treatment is mostly of temporary benefit, but since some of the cases tend to become stationary it is certainly worthy of trial.

Drugs by mouth are of no value, while injections of muscle extracts (e.g. lacarnol) or acetyl-choline only give very fleeting results. The fever treatment with mixed typhoid vaccine is also of temporary benefit, and the patient soon resents the repeated febrile reaction. Two conservative measures, tried recently, appear to give far more promising results. The first of these is the *Pavax* (passive vascular exercise) treatment described by Hermann and Reid in 1933. In this the leg is enclosed in a glass boot and subjected to alternately negative and positive pressure, the object being to encourage the development of the collateral circulation : reports of early results are definitely satisfactory. The other recent measure is intravenous administration of 5 per cent *hypertonic saline* solution in recently sterilised distilled water. This treatment was strongly recommended by Silbert in 1935, who published 524 cases with striking improvement; the injections are given twice to three times a week, starting with 150 cc. and continuing with 300 cc. The hypertonic saline is persevered with while improvement continues. Silbert also insists on the importance of *avoiding cigarette smoking*, which he considers the most important part of the treatment. Recent opinion strongly supports this contention.

Surgical treatment will be resorted to when medical measures fail to arrest the disease. All forms of *sympathetic operations* have been tried, but periarterial sympathectomy, ramisectomy, and adrenal denervation have failed to maintain the success originally claimed for them. Two operations, however, have shown a high proportion of good results in *selected cases*, namely, lumbar ganglionectomy and crushing of the peripheral nerves.

The chief advocates of *lumbar sympathectomy* for thrombo-angeitis are Telford and Stopford, in this country, and Adson and Brown, of the Mayo Clinic. In the article already referred to, Telford and Stopford give the results of 48 lumbar ganglionectomies, 42 of which were bilateral. They had no operation deaths, but six of their patients died subsequently, three of them from coronary disease. Of the remainder, 25 patients (nearly 60 per cent) were classed as good results (no rest-pains, walking well, and at work), 7 were fair results, and 10 (24 per cent) were failures. The best results were obtained in youngish patients with definite vasospasm. There can be no question that sympathectomy should be reserved primarily for cases which show a good vasodilator response after spinal anæsthesia, as these are the only ones in whom the collateral vessels have a chance to vasodilate. Adson and Brown state that only one out of every three patients admitted to the Mayo Clinic proved suitable for this operation. In other cases the

best that can be hoped for it is some relief from rest-pain, and perhaps a lower level of amputation when gangrene supervenes.

Crushing of the peripheral nerves is warmly advocated by White, whose experience with lumbar ganglionectomy has not been too happy; he considers that patients with thrombo-angeitis are not good risks for a major operation, and recommends this minor procedure as an alternative. At least two or three mixed nerves (the anterior tibial, musculo-cutaneous, and posterior tibial) are crushed with artery forceps through small incisions, about six inches above the ankle. This produces a motor, sensory and sympathetic paralysis of the foot, which lasts for three to six months. During this period as much vasodilatation is produced as in lumbar ganglionectomy, and this often proves sufficient to heal ulcers and to limit the spread of gangrene. Moreover, it gives much more complete relief from pain. After six months the nerves regenerate and the vasodilatation comes to an end, but the collateral circulation may have developed in the meantime sufficiently to produce some permanent improvement. In 1935 Smithwick and White reported 29 cases of nerve crushing with 17 cases of marked improvement. The temporary motor paralysis is of little consequence in the foot, but it prevents the application of this procedure to the upper limb. Whatever treatment is adopted a certain proportion of cases (15 to 25 per cent) terminate in gangrene, which necessitates *amputation*. Nerve crushing, lumbar sympathectomy, or the hypertonic saline treatment may limit the gangrene to the toes, and it may be possible to save most of the foot. But when the gangrene shows signs of spreading, or becomes associated with infection, a high amputation may be urgently indicated. As a rule, a below-knee amputation can be done with safety, but when severe spreading infection is present, or the circulation of the stump is doubtful, one should not hesitate to sever the limb through the thigh. Perhaps the most useful test to determine the proper level of amputation is the estimation of the skin temperature; of recent years *arteriography* has also proved of real value in this connection (see page 4017).

Degenerative Arteritis

(arteriosclerosis and endarteritis)

Ætiology.

Degeneration of the arteries (arteriosclerosis) is essentially a medical problem, but it has surgical aspects which require consideration. Although mostly seen in elderly people over 50, arteriosclerosis is not

necessarily a senile process and sometimes occurs in quite young people. Many factors enter into its ætiology, of which toxic states and metabolic disturbances appear to be the most important. Its association with syphilis, nephritis, heart disease, hypertension, diabetes and gout has long been known; it is also known to occur after acute infections, such as influenza and scarlet fever. Recent work, however, suggests that metabolic disturbances constitute an even more important ætiological factor. In diabetic cases arterial degeneration may occur quite early in life, and the present view is that excess of cholesterol in the blood is responsible for it. There are strong reasons for the belief that *disordered cholesterol metabolism* is also responsible for the arteriosclerosis of older people. The morbid changes in the arterial walls appear to be initiated by the accumulation of lipoid cells in the intima, and to a lesser extent in the elastic and muscular coats; necrotic and fibrotic processes follow. Evidence has been recently brought forward which shows that a diet with a high fat content promotes the early development of arteriosclerosis, while a mainly carbohydrate diet with low calorie value is likely to delay it.

Morbid Anatomy.

The morbid changes differ somewhat according to the location of the disease, of which there are two main types: In one, the changes mainly affect the *intima*, constituting a true *endarteritis*. There is a hyperplasia of the sub-endothelial layer, with a large accumulation of lipoid cells, and relatively little fibrosis. The hyperplasia tends to be *patchy* and, owing to poor blood supply, the lipoid patches undergo necrosis and constitute what is known as atheromatous plaques. Sooner or later the necrosis reaches the endothelium and the plaques become *ulcers*, which form the starting-point for *thrombus formation*. Old plaques which fail to ulcerate tend to calcify. This constitutes the type of arterial degeneration usually known as *atheroma*, and is mostly seen in large arteries of the elastic type, such as the aorta, innominate and iliac arteries. The weak areas left in the arterial wall may prove the starting-point of an aneurysm. Quite a different type of endarteritis affects small arteries, particularly those on which the collateral blood supply of a limb depends. Here the usual change is a marked sub-endothelial proliferation, passing on to fibrosis of the intima and media, and leading to marked narrowing and rigidity (obliterative endarteritis). These small vessels thus lose their ability to vasodilate when a special demand for such dilatation is made upon them by occlusion of main channels.

In the large muscular arteries of the limbs arteriosclerosis tends to

be more generalised, and the main changes occur in the *media* (mesarteritis). This becomes the site of a round-celled infiltration, which is followed by necrosis, fibrosis and *diffuse calcification*. The arteries are converted into rigid tubes, with calcareous material deposited in thick rings, but there is not the same tendency to endothelial ulceration and thrombosis as in the intimal type. This type of arteriosclerosis has been termed the Mönckeberg sclerosis, and appears to be associated with hypertension and cardio-vascular strain. The two varieties, however, not infrequently coexist.

Of special surgical interest are the morbid changes which involve the *arteries of the lower limbs* in cases of *arteriosclerotic gangrene*. Marked fibrous thickening occurs in the intima, narrowing the lumen, and spreads to the media and adventitia, while extensive calcification occurs between the intima and media. Fatty degeneration follows, and necrotic patches develop under the endothelium. When the endothelium itself is reached, thrombosis occurs and causes complete occlusion of the vessel (fig. 2205). In diabetes the same changes occur, but at an earlier age. The *smaller branches* of these arteries show intimal thickening, hyaline degeneration, and fibrosis, with marked narrowing, and ultimately obliteration of the lumen. This is the explanation of the poor collateral circulation in lower limb arteriosclerosis, and therefore of the narrow limit of safety which exists between the occurrence of total occlusion of the main artery (e.g. by supervening thrombosis or embolism) and the onset of *gangrene*. In thrombo-angeitis, in diabetic arteritis of young people, and in many cases of arterial embolism, the collateral vessels are frequently unaffected, and there is thus a much wider range of safety between occlusion of a main artery and gangrene.

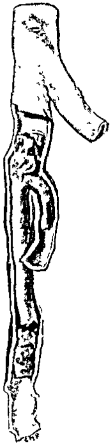

Fig 2205.—ARTERIOSCLEROSIS AND THROMBOSIS OF FEMORAL ARTERY. (*Museum, Royal College of Surgeons.*)

Clinical Course.

The course of arteriosclerosis is generally very slow. The manifestations of greatest surgical interest are those which depend on impairment of the circulation in the lower limbs. The nutrition of the skin, muscles and bones suffers, leading to atrophic changes, while the relative ischæmia causes rapid fatigue, aching pains on walking, paræsthesia,

and intolerance to cold. True intermittent claudication also occurs, but is neither as common nor as severe as in thrombo-angeitis. Cramping pains at night are more frequent and may cause insomnia. The pulses may be feeble and the hardened arteries are usually palpable.

The development of actual *gangrene* is often preceded by signs of increasing arterial occlusion, such as colour changes and marked coldness of the feet, and is sometimes determined by an attack of thrombosis in the narrowed arteries. The direct cause of the gangrene may be trivial, e.g. slight trauma, or a mild local infection, which in a limb with an adequate blood supply would be easily dealt with. The course of the gangrene varies. If the main vessels are not completely occluded, or if the smaller collateral arteries are not seriously affected, the gangrene may remain localised to a superficial patch, or at most it may involve one or two toes. But if either extensive occlusion of the main arteries, or advanced obliteration of the collaterals be present, the gangrene is likely to spread. Infection, by lowering local resistance, by producing a local reaction, and by exciting thrombosis, is another important cause of extension of the gangrene.

Diagnosis.

When one is confronted with a threatening of actual vascular gangrene of the lower limb it is important to ascertain the cause. Vasodilator tests will show whether the vascular lesion is vasospastic or organic: complete failure to elicit a response suggests arteriosclerosis, for even in advanced thrombo-angeitis some vasodilatation is frequently obtainable. The reader must be reminded, however, that occasionally cases of arteriosclerosis are associated with some vasospasm (see page 4029). The diagnosis from thrombo-angeitis has already been considered, but it may be repeated that definite evidence of calcification of the arteries can be obtained by X-ray examination. The histamine wheal test is of special value in the prognosis of arterial occlusion, particularly in diabetic cases: with a good reaction there is no danger of gangrene, but with a negative response gangrene is threatening and special precautions must be taken to prevent it.

Treatment.

From a surgical point of view the treatment of arteriosclerosis resolves itself into two guiding principles: (1) *to prevent gangrene* when this is threatening; and (2) *to treat gangrene* when it has begun. All other aspects of treatment belong to the physician.

In carrying out the first principle, Reid states that every effort must be made to save an affected limb during a critical period, because

a circulatory balance may eventually be established, and gangrene can often be avoided by simple therapeutic measures. Abstinence from fatty food, and treatment of a constitutional cause are of obvious importance. The patient must wear warm and comfortable shoes and stockings, and avoid exposure to cold or damp. Walking must be carefully regulated, and abrasions and other injuries to the feet avoided, while even the most trifling local lesion, such as corns, callosities and ingrowing toe-nails should be treated with the greatest caution. The greatest possible cleanliness and asepsis must be observed. When the local circulation is obviously failing, rest in a horizontal position is essential, the legs being kept at the level of greatest circulatory efficiency. Every attempt should be made to open out the collateral circulation with dry heat, contrast baths, and possibly the Pavæx treatment (see page 4042). A constant temperature foot-cradle devised by Starr and maintaining a temperature of about 35° C. has proved very useful in the treatment of both threatening and actual gangrene. Vasodilator drugs are useless, while the fever therapy with typhoid vaccine is dangerous, as it may start a thrombosis.

Attempts to improve the circulation in an arteriosclerotic limb by operation have, on the whole, proved unsuccessful. *Ligature of the femoral vein* has been of some value in moderate arteriosclerosis with local areas of defective supply, provided the peripheral pulse is still present. It acts by balancing the distribution of the available blood supply to the leg, and occasionally seems to avert threatening gangrene. *Operations on the sympathetic* are of no real value in arteriosclerotic ischæmia, although by producing temporary vasodilatation of collateral vessels they may save an odd case of gangrene here and there. *Periarterial alcohol injections* and *peripheral nerve block* are subject to exactly the same criticism.

When gangrene has actually started, the above conservative measures must be continued with even greater application, in the hope of localising the process. Every care must be taken to keep the gangrene dry and aseptic, and amputation should be withheld until a line of demarcation has formed, unless there is evidence of spreading infection, massive gangrene, or exhausting pain. When an *amputation* has been decided upon, the level at which it is performed is of the greatest importance. For small areas of necrosis with a good line of demarcation the surgeon need only assist nature by dividing a tendon or disarticulating a toe-joint; the resulting wound may already be partly healed, or it may only heal after long delay and repeated breaking down. But when the gangrene is spreading, when infection has occurred, and particularly

when the dorsalis pedis and posterior tibial arteries are not pulsating, a high amputation is essential. Estimation of the skin temperature, and the regional response to the histamine wheal test, may help to determine the proper level of the amputation. But in general one has to choose between a below-knee amputation, which has a low immediate mortality but a greater chance of necrosis in the stump, and a thigh amputation, with its higher immediate death-rate but better prospect of healing.

In recent years, *arteriography* has proved of considerable assistance in determining the best level of amputation for vascular gangrene. By its use accurate visualisation of the main and collateral arteries has been made possible, and the information thus obtained is of obvious importance. For further details and technique the reader is referred to page 4017.

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CHAPTER IV

Aneurysms

CLASSIFICATION

The *term aneurysm is derived from a Greek word which means* dilatation or widening. Its strict pathological meaning is a local dilatation of a blood-vessel, producing either a regular enlargement of the whole lumen (*fusiform aneurysm*), or an irregular enlargement of one side (*saccular aneurysm*). Local dilatation may involve an artery, a vein, or both. A *venous aneurysm* (see fig. 2206) is very rarely encountered as a strictly local lesion, although aneurysmal dilatations are often seen as cyst-like swellings of a varicose vein. *Arterio-venous aneurysms* constitute a fairly common condition, to which a great deal of surgical interest has been attracted in recent years (see page 4072). Unless otherwise specified, however, the term aneurysm is used to designate an *arterial lesion*.

A distinction must be made between a *true aneurysm*, and what has come to be known as a *false aneurysm*. The former is produced by a fusiform or saccular expansion of an artery, and the walls of the aneurysm are thus, at least in part, derived from the walls of the parent vessel. A false aneurysm, on the other hand, is not a dilatation of an artery, but a circumscribed fibrous-walled hæmatoma, produced as the result of extravasation from a wounded or ruptured artery, and preserving its communication with this vessel.

Classification.

An *arterial aneurysm* may be congenital or acquired. *Congenital arterial aneurysms* are extremely rare; they are associated with abnormalities in the development of the vascular walls, and have been described at the base of the brain, in the splenic artery, the internal carotid artery, and elsewhere. Intra-cranial congenital aneurysms are occasionally responsible for fatal subdural hæmorrhage in young people, without trauma or vascular disease (see under Intra-cranial Aneurysms, page 4070).

Acquired aneurysms are conveniently classified into: (1) Spontaneous or idiopathic; (2) traumatic; (3) embolic (mycotic); and (4) erosion aneurysm.

Embolic and erosion aneurysms are of little surgical importance, as neither their course nor their consequences can be influenced by surgical intervention (except in occasional instances). *Embolic* or *mycotic aneurysms* result from the arrest of septic emboli in an artery, with consequent infection of the arterial wall, which softens and gives way, even under normal conditions of blood-pressure. They are usually multiple, are caused by infective endocarditis, are mostly seen in children, and proceed rapidly to fatal rupture.

Erosion aneurysms may be produced by any erosive lesion which

Fig. 23[illegible].—[illegible] aneurysm. (*Museum, St. Mary's Hospital.*)

weakens or destroys the tissues surrounding and supporting an artery, and which invades the arterial walls themselves. The best example is provided by an artery which is left isolated in a tuberculous cavity in the lung: such a weakened and unsupported vessel gradually gives way to the pressure of its blood, dilates to form an aneurysm, and finally ruptures, perhaps causing fatal hæmorrhage. A similar process may affect an artery left stranded in the midst of an acute infective lesion or of a destructive malignant growth. The writer has seen an acute aneurysm develop in a common femoral artery traversing a large abscess, following an infected gunshot wound of the thigh, with compound fracture of the femur; amputation through the hip had to be

resorted to, after all other measures for the control of repeated and alarming secondary hæmorrhage had failed. Another erosion aneurysm of a large artery seen by the writer involved the common carotid, in a case of extensive sloughing of the neck from secondary carcinomatous ulceration; sudden rupture of the aneurysm proved a merciful ending.

Spontaneous and *traumatic aneurysms* are by far the most important varieties from the surgical point of view, and will take up the greater part of this section.

Apart from arterial aneurysms, two other varieties are of surgical importance, viz. *arterio-venous aneuryms* and *cirsoid aneurysms*, both of which will receive adequate consideration.

Idiopathic (Spontaneous) Aneurysms

Ætiology.

Aneurysm is about ten times more common in men than in women. More than 50 per cent of cases occur between the ages of forty and fifty-five. The most common predisposing cause of spontaneous aneurysm is *syphilis*.

The lesion appears to be more common in temperate climates, and among Anglo-Saxon races, but in America there is a high incidence among negroes, probably owing to the prevalence of syphilis in this race. Occupations entailing cardio-vascular strain, especially intermittent increase in blood-pressure (e.g. heavy lifting), and also work associated with repeated trauma of a main artery, are ætiological factors of some importance. It is undoubtedly the exposure to vascular and other forms of trauma which accounts for the much higher incidence of aneurysms in the male sex.

A true aneurysm rarely occurs in a vessel which was previously healthy. The preservation of the arterial calibre, and its resistance to vascular stresses, depends on the muscular and elastic tissues of the *media*. Any condition which interferes with the nutrition and well-being of the media deprives the arterial wall of its resistance to internal pressure, and must thus be regarded as predisposing to the development of an aneurysm. It is because syphilis mostly involves the middle coat of large arteries that it forms such an important ætiological factor. By causing an obliterative endarteritis of the vasa vasorum, and by a direct "toxic" action on the muscle cells and elastic elements, syphilis produces a degeneration of the media. The degenerated tissue is replaced by a connective tissue *proliferation*, and the resistant muscular

and elastic wall becomes an unresponsive and rigid fibrous covering, which can no longer efficiently control variations in the arterial pressure, and is liable gradually to give way before maximal variations.

Syphilis is not the only disease that can produce degenerative changes in the media (*mesarteritis*). Other infective lesions, chronic alcoholism, gout, and some forms of arteriosclerosis are occasionally responsible. Mesarteritis is, of course, a diffuse condition, and when an aneurysm follows it tends, at least in its early stages, to be *fusiform* in shape. The reason why the dilatation of the artery is localised, and not diffuse, probably depends on local effects of vascular strain or external trauma, as well as on the unequal distribution of the more intense degenerative changes.

Apart from diffuse medial fibrosis, syphilis, arteriosclerosis and other infective or degenerative conditions produce changes in the *intima* of large vessels (*endarteritis*), which may also play a part in the causation of aneurysms. Such intimal changes tend to be more localised in their distribution, and are best seen in cases of *atheroma* of the aorta. Local patches of intimal necrosis occur, which sometimes affect part of the underlying media, and the resulting weak spot in the arterial wall may be the starting-point of an aneurysm. Aneurysms formed under such conditions are usually of the *saccular* type, although a so-called *dissecting aneurysm* also develops in the same way.

Trauma undoubtedly plays an important and direct part in the ætiology of true aneurysms. Mostly the trauma is *internal, or vascular*, and is produced by intermittent and marked increases of arterial blood-pressure, such as accompany severe occupational strain, or unaccustomed exertion in elderly men of sedentary habit. Vascular trauma may act with special force on certain points, such as arterial bends (e.g. aortic arch), or where large short arteries undergo a sudden and marked diminution in calibre (e.g. innominate, or common carotid).

External, or rather *extra-arterial trauma*, is a less common ætiological factor of true aneurysms. Such trauma may be repeated, e.g. bending or stretching of an artery during strenuous games and exercise; or it may be single, as in cases where an aneurysm develops at the site of a previous fracture or dislocation. A true aneurysm may also start from a scar in the wall of an artery, which is the result of an old injury.

Morbid Anatomy.

An aneurysm consists of a sac, which communicates with at least one but usually several vessels, and of contents. It is customary to classify sacs into *fusiform*, *saccular*, and *dissecting* (fig. 2207). In the

last type a cleavage occurs through the media, part of which remains in the wall of the artery, while the rest is pushed away with the adventitia by the accumulation of blood in the line of cleavage, to form the sac of the aneurysm. Dissecting aneurysms usually start from an atheromatous ulcer, and are therefore mostly seen in the thoracic or abdominal aorta.

True *fusiform aneurysms,* in which the whole wall of the artery is evenly expanded into a regularly ovoid dilatation, are rarely seen. Aneurysms of large deep-seated arteries, such as the aorta, are often fusiform at first, but subsequently one side yields more than the other, and the aneurysm becomes increasingly sacculated. In a true fusiform aneurysm all the coats of the artery are represented. Thus, it is usually

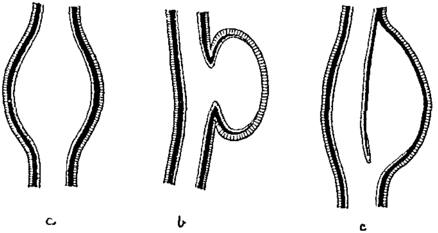

Fig. 2207.—Types of Aneurysm *a.* Fusiform. *b.* Saccular. *c.* Dissecting.

entirely lined by the intima, although this may be irregular and atheromatous in patches. The media is stretched and atrophied, but muscular and elastic tissues are recognisable, particularly near the junctions of the aneurysm with its parent artery. The adventitia becomes much thickened by a peri-aneurysmal fibrosis. Figure 2208 provides a good example of an aneurysm which started as the fusiform variety, but which now shows all the characters of the saccular type.

A large majority of aneurysms are *saccular.* As already mentioned, aneurysms of the large internal vessels may be fusiform at first, but become saccular later. Aneurysms in the limbs are nearly always saccular from the start, largely because trauma plays a dominating influence in their causation. The wall of a saccular aneurysm is profoundly different from the wall of its parent vessel. Although it is true that it may have an endothelial lining, and that the endothelium may regenerate from the parent vessel even after it has been destroyed, the other layers show marked alterations. It may be possible to trace

Treatment.

Since ancient times the treatment of aneurysm has proved of immense interest to both physicians and surgeons. *Medical treatment* has rarely been able to do more than relieve symptoms, and occasionally retard the enlargement of the aneurysm. *Prophylactic treatment*, however, particularly the early and thorough eradication of *syphilis*, is of the utmost value, and is largely responsible for the recent diminution in the incidence of the lesion. Other important preventative measures are: treatment of any general vascular disease, particularly hypertension, and avoidance of undue or unaccustomed strain by predisposed persons.

Most medical methods aim at increasing the coagulability of the blood in the aneurysm, and thus favouring thrombosis. Perhaps the oldest is the starvation treatment advocated by Hippocrates. This has been combined with absolute rest in bed, drugs such as potassium iodide or calcium, intramuscular injections of 2 per cent sterilised gelatin, and repeated bleedings. Real improvement has so rarely attended these remedies that they should be reserved for cases in which no surgical measures can be considered.

Surgical treatment, although rationally employed as far back as the second century by Antyllus, was sadly hampered until asepsis, anæsthesia, and the other great discoveries of modern times, gave surgeons the chance to solve what is essentially a surgical problem. That this solution has been only partly successful is due not to any lack of interest or skill, but to the peculiar difficulties presented by the anatomical situation of aneurysms, which are usually placed astride some vital part of the vascular apparatus.

Surgical measures may be conveniently divided into mechanical and operative, both of which are applied either directly to the aneurysm, or indirectly to its artery.

Mechanical Procedures. These include compression, acupuncture, and the introduction of foreign bodies into the aneurysm.

Compression was a favourite measure in pre-antiseptic days. Its object was to encourage thrombosis and consolidation of the aneurysm, and also to improve the collateral circulation. Direct compression of the aneurysm proved painful and dangerous, but indirect compression of the supplying artery enjoyed a great vogue. Either the fingers or clamps were employed, the compression being applied intermittently. The writer recalls being one of a relay of dressers who, under the supervision of an elderly surgeon, ineffectually squeezed upon the femoral artery, day after day, for a popliteal aneurysm. In these days the only

indication for compression is to increase the collateral circulation, prior to an open operation.

Acupuncture was used by Macewen for inoperable aneurysms, but never became popular. Needles were inserted into the aneurysm in such a way that the blood current made them scratch the opposite intima. It was hoped that this would cause an endarteritis, which might favour clot formation.

Insertion of foreign bodies, such as wire, horse-hair, etc., was employed by Moore, D'Arcy Power and others, with the object of stimulating thrombosis. In a modification of this method, a powerful current is passed through a coil of wire introduced into the aneurysm, which is said to "sear" the intima and so initiate an obliterating arteritis. Inserted wire may also be employed for electrolytic treatment, which is known to cause clotting. Although these methods appear somewhat fanciful, there can be no doubt that they have a limited field of application, especially in aneurysms of the thoracic aorta which can be reached between the ribs by an anterior approach. Satisfactory results have been obtained, and as recently as 1935 Thompson, Souttar and Howells reported a case of aortic aneurysm greatly improved for three years by the insertion of Colt's wire umbrella through a special cannula, the clinical improvement being confirmed radiographically.

Operative Treatment. The operative treatment of aneurysms resolves itself into four main procedures: ligature, aneurysmotomy, excision, and aneurysmorrhaphy. Another operation, brought forward in recent years, is decompression of the sac by arterio-venous anastomosis.

(1) *Ligature* of the artery aims at obliteration of the aneurysm by promoting clotting. Although of great historical interest, its indications in these days are strictly limited. All possible arterial sites and all kinds of ligature material have been employed. The ligature may be applied immediately proximal to the sac (Anel's method), or with the intervention of a branch (Hunter); it may be applied just distal to the aneurysm (Brasdor), or again beyond one or more branches (Wardrop); finally, the artery may be ligated both proximal and distal to the sac (Pasquin).

Although one or other of the above ligature procedures is included in most modern operations, when applied alone they often fail to obliterate the aneurysm, and they rarely insure against recurrence. Failures and relapses are due to *revascular… of the sac by collateral branches.* Inclusion of such collaterals … ·tion endangers the vitality of the limb. Moreover, the … hind and continues to exert harmful pressure effects, … may be displaced into new collaterals and so … For these reasons

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simple ligature often fails to arrest the growth of an aneurysm, and is indeed associated with an actual risk of post-operative gangrene.

(2) *Aneurysmotomy*, in which, after ligature of the main vessels and of the collaterals entering the aneurysm, the sac is incised and evacuated, is a better operation, provided the ligatures are inserted close to the sac. It removes one cause of pressure—the clot, ensures against persistence or recurrence of the aneurysm, and also prevents embolism and thrombosis of collaterals. This operation was first described by Antyllus in the second century, and was recommended 70 years ago by Symes, who modified the procedure by obliterating the openings of the parent vessel from inside the aneurysm. After evacuation, the sac may be pleated, packed, or filled with a muscle graft.

(3) *Excision* of the aneurysm, after near-by ligature of all the vessels communicating with it, is unquestionably the best operative procedure. It produces a permanent cure and removes all relievable pressure effects. Unfortunately it is only applicable to a minority of aneurysms, i.e. those which are accessible, and can be freed from surrounding structures without inflicting such damage as will more than neutralise the benefits of removing the aneurysm.

When excision of the sac can be combined with reconstruction of the main artery, it becomes an ideal operation. But the cases on which this can be done are very few, and the reconstructed artery, which, of course, must be quite healthy, may not remain patent for more than a short period. Of necessity, such reconstruction is usually an end-to-end anastomosis (see page 4084), but in small saccular aneurysms (mostly traumatic) the removal of the sac may leave a one-sided wound of the artery, which can be repaired by lateral suture.

(4) *Aneurysmorrhaphy* was first described by Matas in 1902. Its great advantage is that the operation is performed entirely from within the sac, without disturbing collateral vessels and other extra-saccular structures. It is virtually an eradication of the aneurysm, and in the hands of the originator and his disciples has proved easier and safer than excision of the sac; furthermore, its range of application is somewhat wider than that of excision, although it is still mostly limited to peripheral aneurysms. Whilst it is true that the method has not proved equally successful when tried by other surgeons, it remains a brilliant achievement of conservative surgery.

Endo-aneurysmorrhaphy, to give it its full title, is of three types—*obliterative*, *restorative*, and *reconstructive*. In all types it involves temporary arrest of the blood stream by compression of the main artery proximal to the sac. This may be done by tourniquet, lengths

of wide tape, or artery clamps (see page 4083). The restorative and reconstructive operations can only be performed when the walls approximate to those of a healthy normal artery, and are rarely applicable to other than traumatic aneurysms. In the great majority of spontaneous aneurysms the walls are too degenerated to allow of any but the obliterative operation.

Technique of Endo-aneurysmorrhaphy.

(*a*) *Obliterative* (fig. 2209). One side of the sac is exposed and incised, and the contents emptied. The openings of the parent artery, and of other communicating vessels, are sutured from within. Finally, the sac is obliterated with layers of invaginating sutures.

(*b*) *Restorative* (fig. 2210). This operation is limited to saccular aneurysms with one opening into the parent artery. This opening is

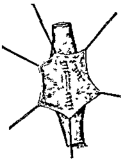

Fig 2209.—Obliterative endo aneurysmorrhaphy.

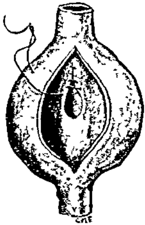

Fig 2210.—Restorative endo aneurysmorrhaphy.

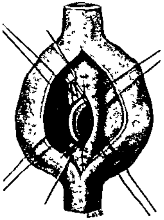

Fig. 2211.—Reconstructive endo aneurysmorrhaphy.

sutured, after incision and evacuation of the sac, again from within, but without narrowing the restored artery. The sac itself is obliterated as before, and at the same time used to strengthen the arterial suture.

(*c*) *Reconstructive* (fig. 2211). This procedure is rarely applicable, being reserved for aneurysms, originally fusiform, in which the two openings of the parent artery are close together, and the wall sufficiently healthy to justify an attempt to reconstruct the artery. A rubber tube is inserted into the two openings of the parent vessel, and a connecting channel is made between them by suturing the adjacent parts of the sac over the tube, which is removed just before the completion of the suture. The rest of the sac is dealt with as before.

Although the restorative operation sometimes succeeds in its object, the reconstructive procedure cannot be expected to do more than provide a temporary arterial channel. In time the reconstructed

artery becomes gradually occluded, but a valuable interval may be obtained for the establishment of an adequate collateral circulation.

(5) *Arterio-venous Anastomosis* (fig. 2212). In 1932, Babcock published an ingenious procedure, which is said to decompress the aneurysm by producing a large arterio-venous anastomosis in its vicinity. It is a hydro-dynamic fact that pressure exerted on the walls of a tube is diminished by increasing the velocity of a fluid running through it. On this principle, Babcock recommends for aortic aneurysm an

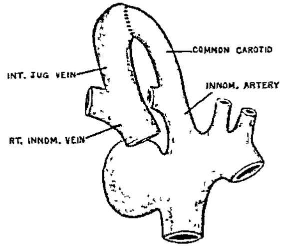

Fig 2212.—Babcock's operation of carotid jugular anastomosis for aortic aneurysm

anastomosis of the cardiac ends of the common carotid artery and internal jugular vein, the distal ends of both vessels being ligatured. This has the object of creating a by-pass, which relieves the pressure of an expanding aneurysm by accelerating the flow of blood through it. Up to 1932 this operation had been performed some 50 times, and it is claimed that pressure symptoms, especially pain, have been relieved, and that the danger of increasing growth and rupture has been lessened. Babcock suggests that the operation might be attempted for aneurysms in other situations.

Traumatic Arterial Aneurysms

In the section on arterial injuries (see page 4007) it was stated that both penetrating wounds and subcutaneous ruptures of an artery are followed by a local extravasation of blood, with the development of an *arterial*

hæmatoma. When the injured artery is large, the wound or rupture extensive, and the surrounding tissues loose and plentiful (e.g. in the axilla, groin or thigh), a very large amount of blood may be extravasated rapidly. The result is a *diffuse pulsating hæmatoma,* quickly growing to a huge size, and producing acute or even fatal anæmia. At first, a penetrating wound of an artery may communicate with the surface, and there may be brisk arterial bleeding. But after a while this ceases owing to shifting of overlying planes, clotting, or suture of the wound. Jagged incomplete ruptures, such as sometimes complicate fractures, and partial transverse wounds often bleed more than longitudinal wounds or complete ruptures.

A rapidly enlarging arterial hæmatoma is in no sense an aneurysm, but it is if anything more serious. The extravasation of blood, apart from endangering life, exerts severe pressure on surrounding structures, and by obliterating the injured artery and collateral vessels it may destroy the vitality of the limb. Associated œdema and a marked inflammatory reaction over the hæmatoma often lead to a mistaken diagnosis of cellulitis or abscess.

When the wound or rupture of the artery is smaller, or the surrounding tissues are firm and closely arranged, extravasation of blood is checked and can only proceed slowly. The result is a circumscribed pulsating tumour, which develops a definite wall of thick connective tissue and laminated clot, and which differs from a true aneurysm only in the fact that the sac is not derived from the walls of the artery, but from a condensation of surrounding fibrous tissue. This is a *false* or *traumatic aneurysm,* and represents a clinical entity of surgical importance, very common in war-time, but also not infrequently encountered in civil life.

Such traumatic aneurysms occur mostly in the arteries of the limbs, since these are particularly liable to injury. The writer has seen them in the common femoral, the profunda femoris, the femoral in Hunter's canal, the popliteal, the brachial, and the radial at the wrist. In civil life, injuries with broken glass (especially in the wrist and forearm), stab wounds, fractures and dislocations, and violent attempts at reduction of these, are the most common causes.

From the point of view of *diagnosis,* a circumscribed traumatic aneurysm presents the same clinical picture as a spontaneous aneurysm, except that the patient is often younger, and the cardio-vascular system is healthy. The history of trauma and the frequent presence of a scar over the swelling facilitate diagnosis. In any case this is rarely difficult, as the aneurysm usually develops in an accessible situation.

Two further points require mention: A circumscribed traumatic aneurysm may start as a diffuse arterial hæmatoma, in which extravasation becomes arrested and the more distal blood clot is absorbed; the area near the injured artery is ultimately walled off by a fibrous capsule, which forms the sac of the aneurysm. The other point is that a traumatic aneurysm may not start to develop until weeks or months after the arterial injury. In these cases the wound of the artery closes after a negligible extravasation, but a weak scar forms, and this yields to some vascular strain at a subsequent period, with the gradual or rapid formation of a traumatic aneurysm.

Treatment.

The treatment of a traumatic aneurysm is essentially operative. The patients are usually young and healthy, and the injured vessel is often quite free from degenerative changes, and so lends itself to restorative operations. There has been considerable difference of opinion as to the optimum time for operation. In the Great War, German surgeons adopted early operative intervention, but French and British surgeons on the whole favoured delayed interference.

Actually the time for operation and the procedure employed will depend on circumstances, which vary with each case. Among these are: (1) *The rate and amount of blood extravasation.* When this is sufficient to endanger life, operation must be undertaken without delay. (2) *The condition of the collateral circulation.* A rapidly enlarging hæmatoma may so obstruct the collaterals as to threaten gangrene, and this danger can only be overcome by early intervention. On the other hand, a circumscribing traumatic aneurysm tends to be associated with gradual improvement in the collateral circulation, which may constitute a reason for delay. (3) *The presence of infection.* This should postpone any attempt to deal with the aneurysm, unless the surgeon's hand is forced by the threat of secondary hæmorrhage. (4) *The condition of the sac and surrounding tissues.* In the first day or two an arterial injury is easy to repair, but after a few days the tissues become infiltrated with fluid and cellular exudate, and are too friable to permit of suture. At the end of some weeks, however, the aneurysm becomes circumscribed, and the surrounding tissues firmer, while the arterial walls are less friable and easier to suture. We can thus conclude that the optimum time for operation is either very soon after the injury, or after a delay of some weeks.

There is no standard operative procedure for traumatic aneurysm, and *surgical technique* can only be discussed in a general way. The first necessity is temporary control of the blood-flow, which is obtained by

one of the methods given on page 4083. Absolute asepsis and a thorough exposure are equally necessary. The reader is referred to the section on arterial ligature (see page 4085) for a description of the best methods of approach to various arteries. The actual operative procedure will depend on the size of the artery, the nature of the injury, the time of the operation, and the changes in surrounding tissues.

Early operation will be mostly needed for wounds or ruptures of large arteries. As there has not been time for the collateral circulation to open out, every effort should be made to restore the main channel. The incision must be made to give good exposure to the injured artery, and need not necessarily be over the hæmatoma. After blood and clots are washed away, the arterial injury is examined and, if possible, repaired (see page 4085). Clean incised wounds are easier to suture than lacerated ones, particularly if they are longitudinal in direction. Complete division or rupture of an artery may be repaired by end-to-end anastomosis, but only when this can be effected without tension. All dead spaces should be obliterated, and the incision closed without drainage.

When the injured artery is unimportant there is, of course, no necessity to repair it. If completely divided, the two ends should be ligatured or closed by suture. A partial division should be completed between ligatures, so that the ends can retract.

Late operation will usually encounter a definite and circumscribed traumatic aneurysm. The treatment of this differs from the treatment of a spontaneous aneurysm only in so far as it more frequently lends itself to restorative procedures. The repair of the injured artery may be undertaken either from within the sac, or outside it ; but it is obvious that the sac itself, being completely non-arterial, must not be used in reconstructing the artery, except perhaps by reinforcing the arterial suture. When the artery has been repaired, the sac is either excised or obliterated by sutures ; the second is the better alternative as it does not entail injury to surrounding structures. Aneurysms of small arteries, however, are best treated by aneurysmotomy or excision, after all communicating vessels have been ligated.

When an injured large artery cannot be repaired, it should be treated by complete division between strong ligatures. In such cases the question of simultaneous ligation of its accompanying vein should be seriously considered (see page 4086).

Surgical Treatment of Special Aneurysms

AORTIC ANEURYSM

Attempts at radical attack are almost invariably fatal, and although sometimes described as heroic, they are not rational procedures. These attempts include proximal ligature, distal ligature, and aneurysmorrhaphy.

There are three minor or indirect surgical procedures which give a fair prospect of temporary relief:

(1) *Paravertebral injections of alcohol* into the upper thoracic sympathetic ganglia, after preliminary novocaine block, can be expected to give complete relief when the aneurysm causes severe pain. In 1935, White reported three cases of painful aortic aneurysm treated in this manner, with complete and prolonged relief.

(2) *Insertion of wire* through a cannula, with or without galvanic or electrolytic currents, has been discussed already (see page 4059), and is worthy of trial when the aneurysm reaches the anterior thoracic wall. Several cases have been greatly benefited by this procedure.

(3) *Arterio-venous anastomosis* (see page 4062) seems to hold out the greatest prospect of real relief. It is based on a sound principle and has already given some striking results.

ANEURYSM OF INNOMINATE ARTERY

Exposure of the innominate artery (see Vol. II, page 1948) is not too formidable a procedure for the modern surgeon, who will not hesitate to remove part of the clavicle and sternum; but treatment by proximal ligature is only occasionally possible, as the aneurysmal dilatation usually involves the adjacent part of the aortic arch. Figure 2213 shows a case where such ligature was performed, but the aneurysm is obviously an early one. The treatment usually recommended is distal ligature of its two branches, i.e. the common carotid and subclavian. To have any real chance of success, the ligature of these vessels must be done simultaneously and as close to the aneurysm as possible. Not infrequently, however, the proximal parts of these arteries are distended by the aneurysmal process, and the ligatures have to be applied beyond an important collateral, such as the vertebral artery. When the carotid and subclavian are ligated near their origin there is serious danger of cerebral complications and of gangrene of the arm; while with any form of ligature, Babcock has shown that the pressure on the walls of

the aneurysm (and thus its rate of enlargement) is increased owing to slowing down of the blood current. For these reasons it seems probable that the best treatment for an innominate aneurysm is an *arterio-venous anastomosis* between the cardiac ends of the common carotid artery and internal jugular vein (see page 4062).

CAROTID ANEURYSM

For some unknown reasons aneurysms of the *common carotid artery* (see also Vol. II, page 1942) are almost as common in women as in men. The most frequent site is near the bifurcation, and pressure symptoms are usually prominent. The problems of treatment are complicated by the danger of *cerebral damage* after sudden

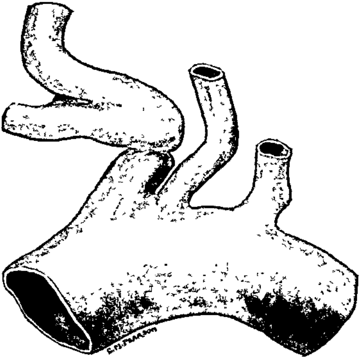

Fig 2213.—Aneurysm of the innominate artery. (*Museum, Royal College of Surgeons*)

complete occlusion of the common carotid, whether by ligature or other procedure. The incidence of cerebral complications has been said to be as much as 25 per cent or more, but it appears to be considerably less than it once was. In young people it is usually quite safe to ligate the artery above and below the aneurysm, which is then excised or obliterated. In patients of over 40, however, it is safer to employ *gradual occlusion* of the artery. This can be done with Halsted's metal bands, or with fascial strips which are tightened in stages. Bell and Tillotson recommend that this gradual occlusion be done distal to the sac, if possible ; it is certainly true that proximal ligature may fail in its object, as it permits reflux of the blood down the external

carotid to reach the internal. This, incidentally, may result in embolism of the latter. If the common carotid *must* be ligated below the aneurysm, the external carotid should be tied as well.

Gradual distal occlusion may result in a cure. If this does not materialise, the collateral circulation beyond the aneurysm may improve sufficiently to allow of a radical operation later. Perhaps the best radical procedure in these cases is *obliterative endo-aneurysmorrhaphy.*

Aneurysms of the extra-cranial part of the *internal carotid* are difficult to treat, particularly the erosion aneurysms which sometimes complicate tonsillar infection, and which are apt to be diagnosed and incised as abscesses. They are very difficult to approach for direct attack, and probably the best method of treating them is by ligature of the common and external carotid arteries. In 1926, Winslow collected 88 cases of internal carotid aneurysm, 43 of which were spontaneous, 18 erosive, and 26 traumatic.

External carotid aneurysms are easily reached and can be dealt with by excision.

SUBCLAVIAN ANEURYSM

This is almost limited to men, and occurs on the right side much more often than on the left; both facts suggest that strain may be an important causal factor. The treatment presents special problems, the most important of which are the anatomical position of the artery, behind the clavicle and very close to the pleura and brachial nerves, and *the danger of gangrene of the arm following sudden occlusion of the artery.*

Although quite recently Elliot advised *proximal ligature,* followed if necessary by distal ligature, with or without excision of the sac, many surgeons would reserve this for cases in which the efficiency of the collateral circulation has been proved by previous compression of the artery. When the aneurysm involves the first part of the right subclavian Elliot recommends *ligature of the innominate,* after resection of the inner end of the clavicle and the adjacent part of the sternum. If temporary compression of the artery shows a deficient circulation, however, a restorative aneurysmorrhaphy is indicated. (See also Vol. II, page 1951.)

AXILLARY ANEURYSM

Aneurysms in the axilla involve the distal two-thirds of the axillary artery, and the upper part of the brachial (fig. 2214), or some of their main branches. They are almost all traumatic in origin, and they tend to enlarge rapidly and to compress the axillary vein and brachial plexus.

Owing to the immediate proximity of important structures, excision of axillary aneurysms is both difficult and dangerous. Ligature,

whether proximal or distal, or both, is associated with a very real risk of gangrene. For these reasons the intra-saccular procedures of Matas are particularly indicated in this situation. Restorative or reconstructive *endo-aneurysmorrhaphy* is the method of choice in definitely circumscribed aneurysms, while the obliterative operation will have to be done if these are impossible. For an imperfectly circumscribed traumatic aneurysm, the sac should be incised, and the wound of the artery repaired by lateral suture.

ILIAC ANEURYSMS

Aneurysms of the common and internal iliac arteries are very rare, but the external iliac artery is not an uncommon site (see fig. 2208). Diagnosis is not made until the swelling has grown to a considerable size. The simplest treatment is distal ligation, i.e of the common

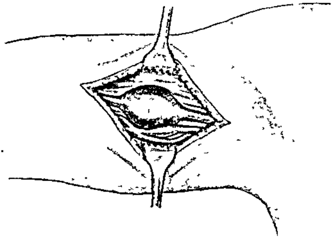

Fig 2214 —TRAUMATIC ANEURYSM OF THE BRACHIAL ARTERY, WITH ACCOMPANYING THROMBOSIS OF THE BASILIC VEINS
(*After Hubert A Royster*)

femoral, but this should not be attempted as it is very likely to lead to gangrene. Proximal ligature is difficult, and is best done with a strip of fascia. Sometimes obliterative aneurysmorrhaphy can be performed successfully, and is undoubtedly indicated whenever possible.

FEMORAL ANEURYSM

Ligature of the common femoral artery is too dangerous to the vitality of the limb to be permissible nowadays. Aneurysms of the common or superficial femoral are mainly traumatic in origin, and are therefore particularly suitable for restorative procedures. Sometimes it is possible to resect the aneurysm and to restore the artery by lateral or end-to-end suture. In other cases a restorative endo-aneurysmorrhaphy may be done. But even if an intra-saccular obliteration proves necessary, this is less dangerous than ligature. For all these procedures satisfactory hæmostasis is provided by temporary proximal occlusion of the artery with a length of tape.

hæmorrhage (see also page 5481). The patient often survives the first hæmorrhage, but recurrences are likely, and any of them may prove fatal. Rarely, the aneurysm does not rupture into the subarachnoid space, but leaks or ruptures into the cerebrum.

Pre-rupture diagnosis is essentially in the province of the neurologist, and can only be discussed briefly here (see also page 5481). The suggestive clinical features are: (1) Recurring migraine-like headaches; (2) involvement of cranial nerves, especially III, IV and VI; (3) loss of visual acuity; (4) pain in the distribution of the trigeminal nerve; and (5) occasionally, symptoms of VII or VIII nerve involvement, and of cerebellar involvement. Various combinations of these symptoms occur, most of them may be absent, and they may all be occasioned by other intra-cranial conditions. Pre-rupture diagnosis is thus extremely difficult, and is only occasionally made. In rare cases auscultation of the skull with a stethoscope reveals a bruit.

Of recent years *radiological* examination has provided much-needed assistance. A stereoscopic X-ray examination of the skull may show a rounded shadow near the brain base. Very recently *cerebral arteriography* (see also page 5483) has been attempted on a large scale by Moniz of Lisbon, and this promises to be of real value in the diagnosis of intra-cranial aneurysms; by this method about 10 cc. of thorotrast is injected into the common or internal carotid, after the artery has been exposed under local anæsthesia.

The diagnosis of *subarachnoid hæmorrhage* is not difficult, and when it occurs spontaneously it is strongly indicative of ruptured intra-cranial aneurysm. Often after a sudden strain, or exposure to strong sunlight, the patient is suddenly seized with violent pain in the occipital region and back of the neck. The pain becomes excruciating, and is soon followed by nausea and vomiting. The patient gradually loses consciousness, but may not do so completely, and passes into a state of cerebral irritation and stupor. The temperature rises to 102 degrees or more, and there is photophobia and marked restlessness. Rigidity of the back of the neck is a common and important sign, but deep tenderness in the nape of the neck is even more constant. Kernig's sign is also generally positive.

The symptoms and signs are obviously those of *meningeal irritation*, and many so-called cases of sunstroke in this country are doubtless examples of ruptured aneurysm. The diagnosis is definitely confirmed by *lumbar puncture*, which yields a deeply blood-stained fluid.

Surgical Treatment.

The treatment of spontaneous subarachnoid hæmorrhage has so

POPLITEAL ANEURYSM

This is much the most common site for peripheral aneurysms. It is only rarely caused by obvious trauma, and yet trauma of some obscure kind is probably often responsible. The aneurysm may be in the upper part of the popliteal space, or low down between the gastrocnemii; in the latter situation it is very liable to lead to gangrene, owing to pressure on important collaterals.

Untreated. these aneurysms usually end in gangrene or rupture. They were formerly treated by one or other type of proximal ligature (see page 4059), but recently this has been abandoned for more direct methods. When possible they should be dealt with by excision, with reconstruction of the artery. In cases in which this is not possible, Matas's obliterative endo-aneurysmorrhaphy finds its most frequent and successful application.

Intra-cranial Arterial Aneurysms

Great interest has been aroused, both in this country and in America, in the origin, diagnosis, and treatment of arterial and arterio-venous aneurysms in the skull (see also pages 4049 and 5498). Arterio-venous (carotid-cavernous) aneurysms present very special problems, and are discussed in another section (see page 4079). Arterial aneurysms are at least as frequent and are certainly more interesting from a neurological point of view.

Although *arterial aneurysms* may develop in and outside the brain in the same way as aneurysms elsewhere, i.e. from *arteriosclerosis, syphilis. septic embolism* (mycotic), and from the *erosion* of neoplastic or infective lesions, the large majority of them are *congenital* in origin. It is particularly with these congenital aneurysms that we are concerned here; the other varieties are not as yet of much surgical interest.

Intra-cranial aneurysms are seen mostly in relatively young patients, with otherwise quite healthy arteries. Their usual situation is in the arteries of the base, and somewhere near or actually in the circle of Willis; the posterior and anterior communicating arteries are favourite sites. They are often multiple, may be very small, or as large as a walnut, and their spherical shape has given them the name of "berry aneurysms." Although occasionally growing into the brain, much more frequently they lie in the subarachnoid space.

Their chief surgical interest lies in their tendency to *spontaneous rupture*, with the production of a sudden and severe *subarachnoid*

hæmorrhage (see also page 5481). The patient often survives the first hæmorrhage, but recurrences are likely, and any of them may prove fatal. Rarely, the aneurysm does not rupture into the subarachnoid space, but leaks or ruptures into the cerebrum.

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Surgical Treatment.

The treatment of spontaneous subarachnoid hæmorrhage has so

far been completely ineffectual. Medical measures do little or nothing to arrest the bleeding, or to prevent recurrence. Measures which lower the intra-cranial pressure (rectal mag. sulph., intravenous hypertonic saline, repeated lumbar puncture, and decompression operations) may relieve cerebral compression, but unfortunately they also tend to increase the bleeding. Nevertheless, one may be forced to use them when increasing compression of the brain threatens to destroy the patient. Fortunately, the hæmorrhage ceases spontaneously in many cases if the patient is left alone and treated with sedatives; but subsequent recurrence is almost certain.

Surgical attack on the aneurysm has until quite recently proved both dangerous and unsuccessful. Ligature of the carotid in the neck usually fails to prevent further ruptures, and, owing to the already impaired circulation in the skull, entails a grave risk of cerebral complications, which include embolism. Intra-cranial attack on the aneurysm by excision or ligature has proved uniformly fatal. In 1933, however, Dott of Edinburgh exposed a leaking aneurysm at the origin of the anterior and middle cerebral arteries, through an osteoplastic flap, and packed muscle grafts round it. This stopped the bleeding, and the patient, who had had three severe hæmorrhages in a fortnight, made a complete recovery, and was quite well two years later. Dott's courageous and intelligent procedure opens up a new and very promising field in the surgical treatment of this dangerous lesion.

Mention must also be made of Babcock's suggestion to treat intracranial aneurysms by an arterio-venous anastomosis (see page 4062). The procedure he suggests is an anastomosis between the *cranial* end of the common carotid and the *cardiac* end of the jugular vein; the object is to diminish the amount of blood reaching the aneurysm, and also to provide a channel whereby blood can escape from the aneurysm into the heart. We do not know whether this operation has actually been performed on a human subject, but it is certainly worthy of trial.

Arterio-venous Aneurysms

Any abnormal communication between an artery and a vein is known as an arterio-venous aneurysm. The great bulk of cases are traumatic in origin, although both congenital and spontaneous groups occur. Originally described by William Hunter, in 1757, the lesion was of

interest in the last century chiefly as a complication of venesection. The occurrence of a large number of cases during the Great War reawakened surgical interest, while of recent years this has been largely focussed on the treatment of one rather common example of the lesion, viz. carotid-cavernous aneurysm.

Pathology.

Arterio-venous communications are of two types: (1) *Aneurysmal varix* (figs. 2215 and 2216), in which there is a simple fistulous opening between closely adjacent vessels (direct communication); and (2) *varicose aneurysm*, in which an arterial hæmatoma forms between artery and

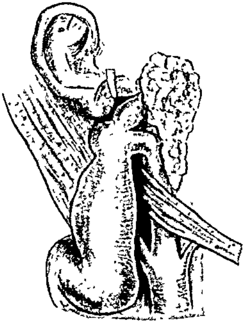

Fig 2215.—Arterio-venous aneurysm of external carotid artery and external jugular vein. (*Modified from Mont R Reid.*)

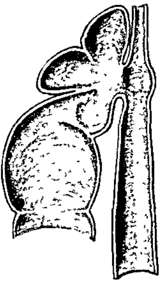

Fig. 2216. Section of specimen depicted in Fig. 2215.

vein, and, becoming surrounded by a connective tissue proliferation, develops into a false aneurysm, into which both the artery and the vein open. Both types are common, although varicose aneurysms predominate in the limbs.

Ætiology.

More than 90 per cent of cases are *traumatic* in origin. Of 447 cases collected by Callander, 189 were caused by bullets and shell fragments, 161 by stab wounds, and 28 by contusions. Arterio-venous aneurysms in the limbs are almost always caused by injuries which involve both artery and vein simultaneously. Such injuries are either lateral wounds or perforations. Carotid-cavernous aneurysms, however, usually result from tearing of the artery alone, the common cause being

a fracture of the middle cranial fossa. Fractures are an occasional cause in the limbs.

Congenital cases are rare, and tend to be multiple. The writer has recently seen a child of seven with a congenital aneurysm between the superficial temporal artery and vein, who had had a similar tumour removed from the forearm some years previously.

Spontaneous cases are rarer still, and are generally produced by rupture of an arterial aneurysm into a neighbouring vein. They are mostly seen in connection with the aorta and the great veins near it.

Morbid Anatomy.

The sites of election for traumatic arterio-venous aneurysms are those in which an artery and vein are enclosed in the same sheath, in an exposed position. They are specially common in Scarpa's triangle, the thigh, the popliteal space, the triangles of the neck, the axilla, the antecubital fossa, and the cavernous sinus.

In the course of development of the aneurysm important changes occur in the vessels themselves, in the fistula or sac between them, and in the local and general circulation. Recent work shows that the most important morbid changes are those which affect the heart.

(1) *Changes in the Vein.* Under the unaccustomed arterial pressure to which it is subjected, the vein dilates both above and below its communication with the artery; at the same time the venous wall becomes hypertrophied or *arterialised*, and tortuous. At first, these changes are localised, but gradually the dilatation spreads distally, and sometimes proximally, until very extensive phlebectases may result. At times the venous dilatation proceeds to an almost grotesque degree. The blood-pressure in the vein may reach 80 or 90 mm.

(2) *Changes in the Artery.* Distal to the aneurysm, the arterial pressure falls and the artery becomes contracted, but proximally it dilates (fig. 2217). In large communications that have existed for months or years the proximal dilatation of the artery may be marked, and may extend for a considerable distance. Degeneration may follow in this dilated portion, and even secondary aneurysms have been known to develop from it.

(3) *Changes in the Communication.* When the communication is a simple fistula (aneurysmal varix) it gradually becomes narrowed by a growth of fibrous tissue round it. Sometimes the contraction of the fistula proceeds to obliteration and a natural cure. In the case of varicose aneurysms, the wall of the intervening sac thickens by increasing fibrous condensation, while its lining becomes gradually covered by endothelium growing from the artery. The sac shows little or no

tendency to enlarge; indeed it mostly tends to shrink. The increasing size of the "tumour" is almost entirely produced by progressive dilatation and tortuosity of the vein. Occasionally, an additional sac develops from the artery on the side away from the aneurysm.

(4) *Effects on the Local Circulation.* The pressure in the vein rises to near the arterial level, and there may be definite venous pulsation. Distal to the aneurysm there is bound to be a degree of arterial deficiency

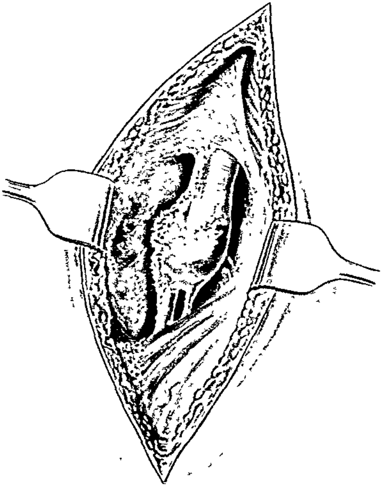

Fig. 2217.—Arterio-venous femoral aneurysm. (*After Mont R. Reid*)

associated with venous stasis. As a result, the nutrition of the part suffers, and œdema, atrophy of the skin and muscles, thickening of the subcutaneous tissues, and occasionally even gangrene, may develop. These changes occur in spite of a very abundant development of collateral channels.

(5) *Effects on the Heart and General Circulation.* As long ago as 1913 Osler described two cases of arterio-venous aneurysm in which death occurred at an early age from heart trouble. A large number of

cases have been published since, which prove conclusively that the shunting of arterial blood into a vein, *when large vessels are concerned*, greatly adds to the strain on the circulation and to the work of the heart. Proximal to the fistula there is a great fall in diastolic arterial pressure, with a compensatory rise in the systolic pressure. The pressure conditions are very similar to those of aortic regurgitation. In addition, there is an increase in the amount of venous blood entering the heart, as well as in the total volume of circulating blood. The pulse is rapid and develops a water-hammer quality.

Under this vascular strain the heart begins to dilate. At first the dilatation is compensated by hypertrophy, but sooner or later decompensation sets in and ends in death. The rate and degree of the cardiac changes are governed by the size of the vessels and fistula. Removal of the aneurysm or closure of the fistula will lead to recovery of the heart, provided the change in circulatory conditions is not too abrupt.

Diagnosis.

A considerable interval usually elapses beween the causal injury and the discovery of the arterio-venous aneurysm. In part this delay may be due to blockage of the fistula by a hæmatoma or a thrombus, which is organised or absorbed later, but it may also be accounted for by the absence of noticeable signs at an early stage of the aneurysm. In congenital cases many years may pass before the patient's attention is drawn to the lesion; indeed cases are on record where the first symptoms which led to advice being sought were those of cardiac decompensation!

The outstanding *local signs* are the presence of a *pulsating lump*, which is usually quite small, *dilatation of veins*, and a characteristic *thrill* and *murmur*.

The *pulsating lump* is mostly produced by great distension of the vein near the fistula. In varicose aneurysm the sac between the artery and vein may also be palpable, but tends to be obscured by the dilated vein. As distinct from arterial aneurysms, the lump is usually small or moderate in size, and does not tend to enlarge.

As a general rule, especially in the lower limb, there is marked *dilatation of the veins* beyond the aneurysm, and not infrequently this leads to a wrong diagnosis of varicose veins. The limb suffers from venous stasis, and may show atrophic and hyperplastic changes, perhaps proceeding to ulceration.

The *thrill* and *murmur* are absolutely diagnostic. Over the aneurysm both are *continuous*, but they show *systolic intensification*. The thrill has a definite "purring" quality, while the murmur has been likened to

the buzzing of a bluebottle imprisoned in a paper-bag. Both thrill and murmur reach their highest intensity at the fistula, where the murmur is also at a higher pitch than elsewhere; this sign assists the exact localisation of the fistula in small or deep-seated aneurysms. The thrill and murmur are transmitted for some distance, both proximally and distally, but away from the aneurysm they lose their continuous nature and become rhythmical and systolic; on compression of the artery proximal to the aneurysm, the thrill and murmur disappear.

General symptoms occur only when fairly large vessels are involved. *There is usually some tachycardia, with a pulse-rate of 80 to 100.* On compression of the aneurysm, the pulse may become slow and the diastolic pressure may rise. This is known as Branham's sign, and is of prognostic importance, as it shows that the heart muscle is not seriously affected. The water-hammer pulse and capillary pulsation may be present with large fistulæ. Cardiac enlargement and decompensation may be the outstanding symptoms when the arterio-venous fistula is between large vessels.

Differential diagnosis from arterial aneurysm presents no difficulty. The absence of progressive enlargement, the presence of a thrill, and the continuous nature of the murmur, should settle any doubt. The removal of oxygenated blood by aspiration of a vein near the fistula is a pathognomonic test. The distinction between aneurysmal varix and varicose aneurysm can sometimes be made by palpation. Otherwise assistance must be sought from radiography.

Treatment.

Small arterio-venous aneurysms, particularly when there is no interposed sac, require no treatment. Even a large aneurysmal varix is probably best left alone, unless it is interfering with the local or general circulation. On the other hand, most varicose aneurysms, and all fistulæ which threaten the well-being of the limb, or produce the least signs of circulatory or cardiac embarrassment, should be operated on.

If an operation is performed at the time of the original injury every effort must be made to preserve the continuity of the vessels, when these are of importance to the vitality of the part. Since the vascular injuries are always partial, both the arterial and the venous wounds can be repaired by lateral suture.

As a rule, however, the case is not seen until some days or weeks have passed. Under such circumstances a period of *delay* is advisable, to allow the vessels and other tissues to recover from the initial trauma, and also to give time for the development of an adequate collateral circulation.

The following *operative measures* are available for the treatment of arterio-venous aneurysms: (1) Proximal ligature of the artery; (2) proximal and distal ligature of the artery; (3) ligature of the vein; (4) quadruple ligature; (5) ligature of the fistula; (6) restorative procedures; and (7) excision.

Proximal ligature is dangerous, whether it is near the aneurysm or at a distance. In the extremities it is often followed by gangrene, while ligature of the carotid for cavernous aneurysm may cause cerebral complications. The danger of ligature can be diminished by performing partial occlusion (with metal bands), or by employing intermittent compression for a period, with the object of enlarging the collateral paths.

Double ligature of the artery may be performed for small varicose aneurysms, but it is preferable to tie the vein as well.

Ligature of the vein is of little use, as it merely converts the aneurysm into an arterial one.

Ligature of the fistula may be attempted for an aneurysmal varix with a narrow communication, but there is danger of the ligature cutting through.

Quadruple ligature (double ligation of artery and vein) with *excision of the aneurysm* is the best procedure for cases unsuitable for reconstructive surgery. This may entail a tedious and difficult dissection, but it is safer than quadruple ligature alone, which is very liable to be followed by gangrene. *An efficient collateral circulation is, of course, vital to the success of these operations*, and every effort must be made to improve it by preliminary compression and other measures. When the vitality of the part is in doubt, the surgeon has no choice but to attempt a restorative procedure, even if the chances of a successful issue are small.

Restorative procedures should be aimed at for all large fistulæ. An aneurysmal varix is best repaired by opening the vein opposite the communication, after provisional arrest of the circulation (see page 4083), suturing the fistula from that aspect, and then repairing the incision in the vein. When the fistula is wide and short, it may be wiser to divide it from the outside, and then to suture the lateral wounds of the artery and vein thus produced (for vascular suture see page 4084).

For a varicose aneurysm the ideal procedure is excision of the sac and repair of the lateral openings in the artery and vein by suture. In difficult cases the vein should be excised with the sac, and only the artery repaired. When the sac cannot be isolated with safety, some form of endo-aneurysmorrhaphy is indicated; the simplest procedure is to

expose part of the sac and open it, and then to suture the arterial and venous openings as well as any collaterals, from within the sac. The sac itself is obliterated by invaginating sutures.

CAROTID-CAVERNOUS ANEURYSMS

This is one of the most common forms of arterio-venous aneurysm; in 1935 Dandy stated that there were over 800 cases in the literature. In its cavernous part, the internal carotid artery is separated from the blood in the cavernous sinus by a single layer of venous endothelium. To produce an arterio-venous fistula, therefore, it is only necessary for the carotid artery to give way. More than three-quarters of the cases are *traumatic* in origin, the usual cause being a fissured fracture through the middle cranial fossa; gunshot wounds, and punctures of the orbit are occasionally responsible. The remaining cases are either *congenital*, or caused by atheroma or other degenerative *arterial disease.*

Clinical Features.

Symptoms may start soon after the injury, or they may be delayed for months. The main features are: (1) *Pulsating exophthalmos*; (2) *a subjective roar*, which may be continuous, or mostly systolic, is intensified by stooping, and may be diminished by compression of the carotid in the neck; (3) a systolic or continuous *bruit*, which can be heard over the temple, forehead or eyeball; (4) *pain* may or may not be present, and it may be local or take the form of a widespread headache; (5) *dilatation* of the orbital and perhaps the forehead *veins*; (6) swelling of the lids and conjunctiva (*chemosis*); and (7) *ophthalmoplegia* and *optic neuritis*, which vary in severity.

Treatment.

The aneurysm may be attacked either from the arterial or from the venous side; both methods aim at securing thrombosis in the fistula itself, or on one or other side of it, in the hope that this will be followed by fibrous obliteration of the fistula, and so produce a cure of the aneurysm.

Attack from the *venous side* has been carried out by ligature of the ophthalmic veins, by diathermy, and by injection of sclerogenic and coagulating solutions into the ophthalmic veins. None of these methods has proved really successful, although occasional benefit appears to result.

Arterial attack usually consists of ligature of the common or internal carotid in the neck. Ligature of the *internal carotid* is the better procedure, but if the common carotid is occluded the external carotid should be ligated also. Unfortunately 15 to 20 per cent of cases treated

in this way develop cerebral trouble, which may prove fatal. To prevent this, Matas in 1935 advised preliminary intermittent compression, which should be done by the patient, or by a team of assistants, and continued until long periods of compression produce no cerebral symptoms. As an alternative, the carotid occlusion may be done gradually, by using metal bands which are tightened in stages.

Carotid ligature always produces an immediate improvement, with cessation of the distressing roar, retraction of the eyeball, and improvement of vision: but in 24 hours some of the symptoms begin to

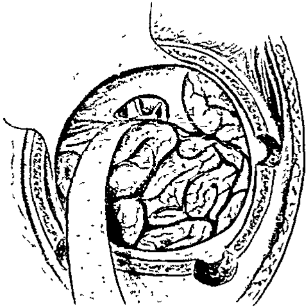

Fig 2218.—Dandy's intra-cranial carotid occlusion for carotid-cavernous aneurysm. (*After Dandy*)

return. Whether permanent relief is obtained or not depends on efficient occlusion of the fistula by thrombosis and organisation of the clot. Matas states that 40 to 50 per cent of cases are cured, and others relieved, but some 30 per cent or so ultimately relapse.

For relapsed cases after ligature of the carotid in the neck, Dandy recommends an intra-cranial occlusion of the internal carotid by a silver clip (fig. 2218), after it emerges from the cavernous sinus and parts with its ophthalmic branch. He employs the frontal pituitary approach through a trap-door osteoplastic flap, and has performed the operation twice with marked success. The procedure is a distal ligature on the *Brasdor principle*.

Cirsoid Aneurysms

A cirsoid aneurysm is a remarkable development of dilated and tortuous vessels, forming a characteristic vascular tumour, which has been likened to a mass of pulsating worms. It is mostly seen in the *scalp*, particularly in the distribution of the temporal and frontal vessels. The condition is nearly always *congenital* in origin, but *trauma* seems to play a contributory part in its causation. Although it may start quite early in life, some cases do not begin until puberty or later, but even these usually develop in a congenital vascular defect, such as a *nævus*.

The *pathogenesis* of this interesting lesion undoubtedly depends on the existence of multiple *congenital arterio-venous communications*. In a region so full of blood-vessels as the scalp, it is evident that these fistulæ will result in what amounts to numerous arterio-venous aneurysms. The vessels undergo the changes one might expect (see page 4047). The veins dilate, and become tortuous and thick-walled ; they pulsate and are, in fact, arterialised. The arteries also dilate and degenerate, and secondary aneurysms develop from them. Owing to pressure-erosion the dilated arteries and veins break into one another, with the formation of secondary communications. In this manner, a kind of vicious circle is produced, more and more vessels are involved, and the lesion increases in size and extent, until almost the whole scalp is involved. In the worst cases the skull becomes eroded.

Clinical Features.

The diagnosis of the condition presents no difficulties. The mass of *tortuous, dilated and pulsating vessels cannot be anything but a cirsoid* aneurysm. The most distressing symptom is a *constant humming noise*, which is very disturbing to the patient, and may lead to nervous complications. It is, of course, easily heard on auscultation. Severe headache and a sense of heat may also be complained of.

Treatment.

An enormous variety of therapeutic procedures have been tried, but most of them have ended in failure. This is particularly the case with injections of sclerosing and coagulating substances, and with the older procedures of cauterisation and electropuncture. But it also applies to limited ligature operations.

A small area of cirsoid formation can be completely excised with little risk of recurrence. But a large lesion is both difficult and dangerous to treat by radical methods, unless these are conducted in

stages designed to lessen the size and vascularity of the mass, prior to excision.

The following procedure for large cirsoids is recommended by McNealy: the first step is *preliminary ligature of the external* carotid. After a week, this is followed by ligature of main branches, such as the superficial temporal, posterior auricular, etc. After another week, the large vessels entering and leaving the tumour are tied near its edge. These procedures will reduce the size and the intense vascularity of the tumour to such an extent that excision of the whole mass, or of the greater part of it, becomes feasible, and is freed from the danger of uncontrollable hæmorrhage.

Cirsoid aneurysms occasionally occur in the limbs, and very rarely in the brain.

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CHAPTER V

Suture and Ligature of Arteries

ARTERIAL SUTURE

Suture of arteries has become a safe and satisfactory operation. The reasons for its recent success include reliable asepsis, apposition of intima to intima, the use of fine vaselined or oiled silk, and the exercise of meticulous care and gentleness. By these means thrombosis can be averted, especially in healthy arteries. Arterial suture has revolutionised the treatment of wounds of large vessels, such as the common carotid, subclavian, axillary, external iliac and common femoral. It also forms an essential part of the operations of embolectomy and aneurysmorrhaphy.

The following rules must be strictly observed: (1) Absolute asepsis is essential; (2) the intima of one side of the wound must be brought into accurate apposition with the intima of the other side, and no part of the media or adventitia should be allowed to come in contact with the blood stream; (3) the greatest care must be taken to avoid injury to the arterial wall, especially to the intima; (4) the intima must be kept moist with citrate solution, and should not be scratched or picked up with forceps during the suture; and (5) the choice of needles, sutures, etc., should be governed by the need to avoid thrombus formation.

In the actual *technique* of suture, the first step is adequate exposure of the wounded artery, and the second step is the *temporary occlusion* of the vessel. It is essential that this occlusion be effected without inflicting the slightest damage on the arterial wall. For the closure of a small punctured wound efficient hæmostasis can be obtained by gentle compression of the artery with the fingers of an assistant, or by passing a piece of broad tape round the artery and holding it moderately taut. For more serious wounds, which will require more time, the best agent to employ is a smooth-jawed, rubber-covered artery clamp, with a rather weak spring.

There are two types of arterial suture, *lateral suture* (see fig. 2219) and *end-to-end anastomosis* (see fig. 2220). In both it is necessary to

evert the edges, so that intima is brought into contact with intima. This is best done with interrupted mattress sutures, using very fine sharp needles, and the finest oiled or vaselined silk. Very fine catgut has also been used with success, but it is undoubtedly safer to employ silk. The everted edges are then further secured with a few interrupted sutures, and the clamp released.

In *end-to-end anastomosis* for a complete division or rupture of a large artery, some difficulty may be encountered in bringing the retracted ends together without tension, but unless this can be done the operation should be abandoned for ligature. Sometimes a segment of the artery may have to be excised because it is extensively bruised,

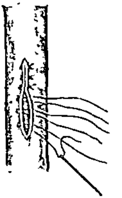

Fig 2219.—Suture of lateral wound of artery

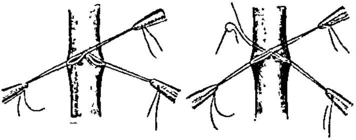

Fig 2220.—End-to end anastomosis of artery.

or for some other reason (see page 4020). In many cases even a wide gap can be bridged successfully by positional relaxation (e.g. flexion of the thigh for the femoral artery), or by freeing both ends of the artery for some distance by careful dissection. Having obtained an easy apposition, the actual anastomosis is greatly facilitated by passing three traction sutures at equidistant points, so that when these are pulled on the anastomosis is *converted into an equilateral triangle* (fig. 2220). Each side of the triangle is now sewn separately, with everting mattress sutures. After release of the artery clamps, the suture line must be carefully watched for a few moments, as it may be necessary to reinforce it.

During the performance of arterial suture, provision must be made to prevent clot formation. The wound and the lumen of the occluded artery may be washed with sodium citrate solution, or the intima of the artery at and near the suture should be lightly smeared with sterile paraffin.

Exposure and Ligature of Arteries

GENERAL PRINCIPLES

Ligature of an artery is mostly needed for the *arrest of hæmorrhage*, which is usually caused by an external wound, accidental or operative ; arterial hæmorrhage may also be produced by subcutaneous rupture of a vessel, or by its invasion in an erosive or ulcerative process. Under these conditions the surgical procedure employed for the arrest of bleeding is always more or less an emergency operation.

There are, of course, many other indications for arterial ligature. Its employment in various forms of *aneurysm* has been fully considered. It is also used in the treatment of *toxic goitre*, to diminish the size of some *tumours*, and in the course of many *surgical operations*, e.g. as a preliminary to resections of the tongue, colon, uterus, etc.

The ligature of *small arteries* is hardly ever done except for the arrest of bleeding. When the artery is completely divided, both ends are picked up as cleanly as possible (i.e. with a minimum of surrounding tissue) by artery forceps, and tied moderately firmly with a reef-knot of rather fine catgut. An intact artery which is exposed during an operation and which needs division, also an artery which is incompletely severed, should be picked up with two pairs of forceps, and divided between them ; it is then treated as a divided artery.

Ligature of a *large artery* is an important surgical operation, by no means free from risk. Classical methods of exposure and ligature are now of chief interest to candidates for the operative surgery examination, and have been very largely replaced by methods better adapted to modern requirements. There are certain *principles* and *general rules* which govern modern ligature procedures, and which are tabulated below :

(1) *Incisions* along the anatomical line of an artery do not always provide the best access to an injured vessel. In the types of injury prevalent in these times (traffic and industrial injuries, and war wounds) very free exposure is often needed, since other important structures besides arteries will be damaged. *The incision must, therefore, be planned to provide the necessary exposure for each individual case.*

(2) *Arteries should not be tied in continuity*, unless the occlusion is to be temporary. Ligation in continuity is often followed by absorption of the ligature and recanalisation or absorption of the thrombus. When an intact artery is to be occluded, it should be tied in two places,

and divided between the ligatures. These should be placed a fair distance apart, so that a good cuff projects from each end; the cuffs granulate and develop into firm plugs of fibrous tissue.

(3) The ligatures should be tied firmly enough to *damage the intima* (otherwise clotting will not occur), but *not so as to rupture the media.* After ligation, thrombosis extends up to the nearest collateral, and by organisation converts the artery into a fibrous cord.

(4) The danger of fracturing the arterial wall is particularly great in large arteries, the damage being done by the force of arterial pulsation against the tightening ligature, rather than by the ligature itself. In such cases there is a real risk of the ligature cutting right through the arterial wall, with fatal hæmorrhage. To avoid this danger, Reid advised (1934) that the artery should be temporarily occluded by proximal and distal compression during the application and tying of the ligature.

(5) In the occlusion of large arteries *non-absorbable* ligature material should be employed. Catgut may begin to fray and be absorbed before the artery is safely consolidated. The thickness of the ligature depends on the size of the artery. Fine ligatures cut through the wall more rapidly than coarse. Arteries of large size are best tied by Ballance's stay-knot (fig. 2221). Coarser ligatures should be used for arteries tied in continuity than for a divided artery.

(6) The blood-flow in the territory of a ligated artery is re-established, in the first place, by vasodilatation of the collaterals. This vasodilatation, however, is temporary, and the ultimate fate of the ischæmic territory depends on the amount of permanent collateral supply which develops in time to keep the tissues alive. It has been shown conclusively that resection of a segment of the artery (arteriectomy) increases the vasodilator response, and so tends to preserve the vitality of the ischæmic area.

(7) Simultaneous *ligature of the companion vein* also quite definitely improves the blood supply of the territory of an occluded artery, and should always accompany ligation of a main artery. It acts by " balancing " the available circulation, by increasing the capillary tension, and by distributing what blood is left in the part. Although this procedure was warmly advocated by Makins many years ago, its general acceptance is of very recent date. Experimental work published by Brooks and Johnson in 1934 shows that by simultaneous vein ligature the incidence of gangrene was reduced from 29 per cent to 2 per cent.

(8) In general, a divided artery should be ligatured *where it is bleeding.* More proximal ligation may fail to arrest hæmorrhage,

owing to the presence of collaterals beyond the occlusion. The *distal end* must also be ligatured, whether it is actually bleeding at the time, or not; otherwise it will fill from collaterals and bleed later.

(9) After completing the ligation, the wound must be closed completely, and without drainage.

GENERAL TECHNIQUE

Temporary arrest of hæmorrhage, if any, has been already effected by a tourniquet, direct or indirect pressure, or by some other method (see pages 4003 and 4083). The patient or limb is placed in a suitable

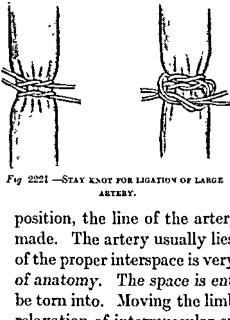

Fig 2221 —Stay knot for ligation of large artery.

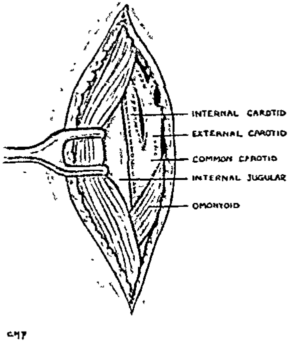

Fig 2222.—Exposure for classical ligature of the common carotid artery or its branches.

position, the line of the artery visualised, and an appropriate incision made. The artery usually lies in an intermuscular space. Recognition of the proper interspace is very necessary and requires a good knowledge of anatomy. The space is entered into with a scalpel, and must never be torn into. Moving the limb helps in both the identification and the relaxation of intermuscular spaces. The approach to the artery must not be through a shelving wound, since the deep parts require as free an exposure as do the superficial tissues. If the depths of the wound can be clearly seen, there is no difficulty in finding the artery, or in distinguishing it from accompanying veins and nerves.

The first view of the artery will be through its sheath. This is

picked up with toothed forceps and nicked with a fine scalpel on the flat. The lifted sheath is then divided for the distance required, and the artery freed with a dissector. Classically, the ligature is applied on an aneurysm needle, which is passed round the vessel, away from its most dangerous neighbour; with free exposure, however, it matters little how the ligature is placed round the artery. What matters is that the artery should be properly freed so that it is ligatured cleanly, that the ligature should be properly and securely (but not tightly) tied, and that the general principles just enumerated should be strictly observed.

EXPOSURE AND LIGATURE OF THE LARGER ARTERIES

Common Carotid Artery (see also Vol. II, page 1942).

(1) When the intact artery is to be ligated, e.g. for intra-cranial aneurysm, the *classical method* is quite adequate (see fig 2222). The shoulders are raised, a sand-bag is placed under the neck, and the head turned to the opposite side. A 3-inch incision is made along the front edge of the sterno-mastoid, its centre being opposite the cricoid. The external jugular vein is identified and retracted, or divided between ligatures. The deep fascia is incised, the sterno-mastoid retracted outwards, and the anterior belly of the omo-hyoid looked for and hooked down. The carotid sheath is now easily seen. It is opened on its inner side, avoiding the ansa, and the common carotid is brought into view near its bifurcation. Care must be taken to separate the artery from the internal jugular vein, which overlaps it, and from the vagus nerve, before applying the ligature. Fascial strips or tape are preferable to other ligature materials.

(2) For gunshot wounds and other injuries implicating the common carotid or its branches, a much more *extensive exposure* will be required (fig. 2223). A flap should be raised down to the deep fascia, the incision running along the front edge of the sterno-mastoid to the sternum, and then along the upper border of the clavicle. The flap is turned back and the deep fascia carefully incised along the sterno-mastoid border. A finger is passed under the sternal and clavicular heads of the muscle, and these are divided an inch or so above their origins. The sterno-mastoid is now retracted backwards, and the omo-hyoid hooked downwards. The carotid sheath is thus exposed through its entire length, and the common, external, or internal carotid arteries, as well as the internal jugular vein, can be dealt with as required. At the end of the operation the sterno-mastoid is reconstructed with mattress sutures.

External and Internal Carotid Arteries.

(1) For ligature of the intact arteries, the *classical method*, as described for the common carotid, will give all the access required. By centring the incision on the cricoid, not only the carotid bifurcation, but also the *origins* of the internal and external arteries, are easily brought into view. When it is desired to tie the external carotid higher

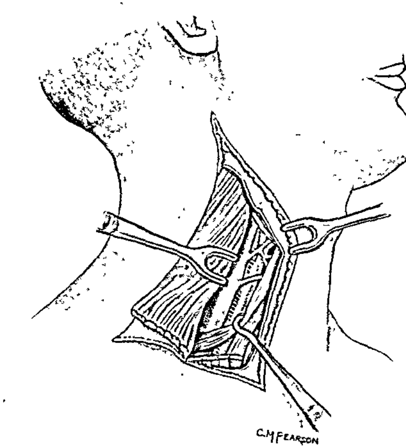

Fig. 2223.—Wide exposure of carotid vessels for wounds of neck.

up or to ligate one of its branches (e.g. the lingual, superior thyroid, or facial), the incision is made at a slightly higher level.

After incising the carotid sheath, the jugular vein is freed and retracted *inwards*, and the carotid bifurcation is exposed. The external carotid can be distinguished from the internal by the fact that it gives branches. Care must be taken not to injure the hypoglossal nerve, its descendens branch, or the superior laryngeal nerve which lies deep to both carotid arteries.

(2) For *deep wounds high in the neck*, in which an injury of one of the carotids, or of a large branch, is suspected, a particularly *free exposure*

is essential (fig. 2224). The best incision is one which runs up the anterior border of the sterno-mastoid from the cricoid to the mastoid process, and then curves back over the latter. The tip of the mastoid is detached with a chisel, and pulled back with the sterno-mastoid muscle. The posterior belly of the digastric is now seen, freed carefully, and divided on a director. A very complete exposure of the upper part of the carotid vessels and jugular vein is thus obtained, as well as of most branches of the external carotid. At the end of the operation, the two

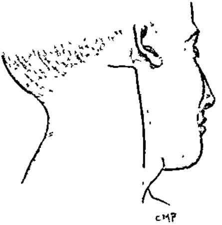

Fig 2224.—INCISION FOR EXPOSURE OF UPPER CAROTID REGION.

halves of the digastric are stitched together, while the tip of the mastoid is re-attached with sutures through the periosteum.

Subclavian Artery (see also Vol. II, page 1951).

The *classical methods* of ligaturing the subclavian give a very cramped approach particularly in stout and short-necked patients. Except for being severe tests of surgical skill, they have nothing to recommend them, and are quite unsuitable for the treatment of wounds.

The *modern method* entails division of the clavicle and provides the exposure which is needed in the treatment of injuries (fig. 2225). The patient lies with his shoulder over the edge of the table and a sand-bag under his back. The incision is roughly T-shaped, the horizontal part just above the clavicle, and the oblique part from near the inner end of the first incision, downwards and outwards in a curved manner, to the axilla. The pectoralis major is completely divided in the line of the oblique incision, and the pectoralis minor is cut across near its insertion, after it is hooked up with the finger. The exposed costo-coracoid membrane and deep pectoral fascia are now incised up to the clavicle. The clavicle is then cleared a little medial to its centre, two

holes are drilled through it, and it is divided with a small saw or chisel between the drill-holes ; a guard must be inserted under the bone while this is done.

This approach provides a wonderful exposure of a region of the utmost importance, and gives access to both the subclavian and the

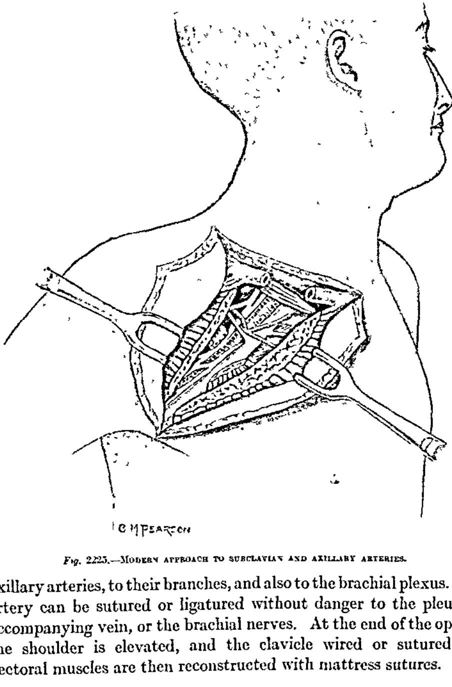

Fig. 2225.—Modern approach to subclavian and axillary arteries.

axillary arteries, to their branches, and also to the brachial plexus. Either artery can be sutured or ligatured without danger to the pleura, the accompanying vein, or the brachial nerves. At the end of the operation the shoulder is elevated, and the clavicle wired or sutured. The pectoral muscles are then reconstructed with mattress sutures.

Axillary Artery.

The first and second parts are best exposed by the preceding method,

although the *classical ligature of the first part* is a very pretty examination exercise, and deserves a brief description. A curved incision is made half an inch below the middle two-fourths of the clavicle. The pectoralis major is incised through its whole thickness, and the pectoralis minor retracted downwards. The costo-coracoid membrane is then divided along the upper border of pectoralis minor, care being taken not to injure the axillary vein, which is attached to it. The axillary artery is now exposed, with the vein on its inner side, and the brachial cords outside and behind it. An aneurysm needle is passed from the inner side, to avoid the vein.

The *third part* of the axillary artery can be exposed by an upward prolongation of the incision for the brachial artery. Care must be taken of the basilic vein, which is here joining the brachial venæ comites to form the axillary vein, on the inner side of the artery. The cords of the brachial plexus are giving off their respective nerves, and are disposed on all sides of the artery. They must be identified and hooked out of the way.

Brachial Artery.

The *classical approach* gives an adequate exposure of the brachial artery. The arm should be abducted, with the forearm (not the upper arm) resting on a small table, while the surgeon sits between the patient and the arm. A free incision is made in the line of the artery (middle of clavicle to middle of antecubital fossa), between the inner head of the triceps, on which the artery lies, and the belly of the biceps, by which the artery is overlapped. The biceps is now retracted upwards (towards the ceiling), care being taken not to include the artery in the retractor. The median nerve is usually seen first as it is crossing the artery from without in: it is freed and pulled out of the way. The artery is then dissected away from its accompanying veins, and dealt with.

Bifurcation of the Brachial Artery and its Branches (fig. 2226).

Wounds in the antecubital fossa and the upper part of the forearm may implicate any one or more of the following arteries: the brachial, the ulnar, the radial, the common interosseous, or their branches. The freest possible exposure is therefore necessary for arterial injuries in this region. The position of the arm is as for ligature of the brachial artery. A 4-inch incision is made, starting well above the antecubital fossa and to the inner side of the biceps tendon, and curving downwards and inwards over the supinator longus. The deep fascia and the semilunar expansion of the biceps are incised, after ligating the median basilic vein. The space between the supinator longus and pronator teres is opened up by wide retraction of these muscles, after the inter-

muscular interval is defined by running a dissector down it. The end of the brachial artery is now seen, with the radial and ulnar arteries arising from it, and the median nerve on its inner side. By rotating the hand, and retracting more forcibly the muscle which is mostly in the way, either main branch can be followed for some distance; the common interosseous can also be exposed for the short portion above the hiatus between the oblique ligament and the upper edge of the interosseous membrane.

Iliac Arteries.

The *common* and *internal iliac* arteries should always be exposed by the transperitoneal route. The abdomen is opened by a median sub-umbilical incision, the patient placed in the Trendelenburg position,

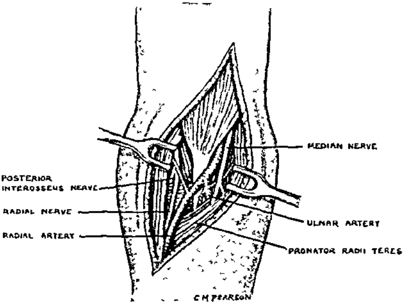

Fig 2226.—Wide exposure of arteries in antecubital fossa and upper third of forearm.

and the intestine packed out of the way. The desired artery is easily found, the peritoneum over it is incised, and the artery cleared and dealt with. The ureter must always be identified, as it crosses the bifurcation of the common iliac artery, and runs down the lateral pelvic wall in front of the internal iliac vessels.

The *external iliac* artery is best approached by a modification of Abernethy's classical extra-peritoneal method: An incision is made $\frac{3}{4}$-inch above the outer two-thirds of Poupart's ligament. The external oblique aponeurosis is divided, the inguinal canal opened up, and the arching fibres of the internal oblique defined and incised near their origin from Poupart's ligament (fig. 2227). The deep epigastric vessels are now seen and divided between ligatures. The transversalis fascia is exposed in the floor of the wound and is incised, also near its

attachment to Poupart's ligament. This exposes the peritoneum, which is peeled off the psoas and iliacus with the fingers. The external iliac vessels are thus brought into full view (fig. 2228).

Femoral Artery.

The *common femoral* should not be ligatured owing to the grave risk of gangrene; every effort must be made to reconstruct the artery in cases of injury, by lateral suture, or even by end-to-end anastomosis. When ligature cannot be avoided, the vein should be tied as well.

Exposure of the *superficial femoral* (fig. 2229), either in Scarpa's triangle or in Hunter's canal, is quite easy. The thigh is slightly flexed, abducted, and everted. An incision is made in the line of the artery (from the mid-point between the anterior superior spine and the symphysis to the adductor tubercle). The fascia lata is divided, and the flat sartorius

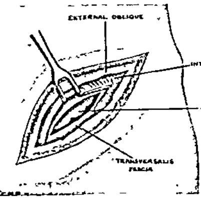

Fig 2227.—LIGATURE OF EXTERNAL ILIAC ARTERY. 1st Stage

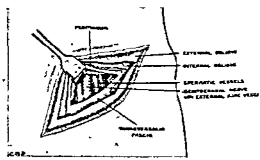

Fig 2228.—LIGATURE OF EXTERNAL ILIAC ARTERY. 2nd St

belly identified and retracted; to expose the artery in Scarpa's triangle, the sartorius is pulled outwards, but in Hunter's canal a better approach is provided by retracting the muscle inwards. In the triangle the artery is exposed at once, but in Hunter's canal it lies embedded in some areolar tissue and roofed over by a fibrous expansion, and a little dissection will be needed to bring it into view.

Arteries in Upper Part of Popliteal Space.

The femoral artery where it comes through the adductor magnus, and the upper part of the popliteal artery, lie very deeply, and a *very free approach* is required to give adequate exposure in this important region. The leg is placed on a small table some distance away from the operating table, and is held by an assistant, with the thigh abducted and everted, and the knee flexed. The surgeon stands between the two tables, facing the inner aspect of the thigh. A long incision is made, starting at the adductor tubercle and running up along the line of the

artery. The sartorius is seen in the front part of the wound; it is freed with the finger and retracted forwards. The adductor magnus tendon is exposed in the middle of the wound, with the semimembranosus behind it. The adductor magnus tendon is freed from its connections with the finger, and retracted well back. The aponeurotic expansion between it and vastus internus is thus put on the stretch; it is carefully incised, and retracted, and the femoral artery is exposed in the lower end of Hunter's canal, with the vein behind it. After a little dissection, the artery can be followed through the adductor opening, and into the popliteal space.

Lower Part and Bifurcation of the Popliteal Artery.

The patient lies prone, and the foot is controlled by an assistant. A 4-inch vertical incision is made between the two heads of the gastrocnemius, which are identified, separated by dissection, and widely retracted. The external saphenous vein and nerve are previously looked for and hooked aside. The internal popliteal nerve is now seen, and under it are found the popliteal vessels, the artery being the deeper of the two. The nerve is gently hooked aside, and the vessels freed by dissection until they disappear under the soleus.

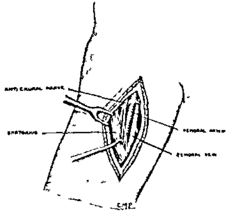

Fig 2229.—Exposure of femoral artery.

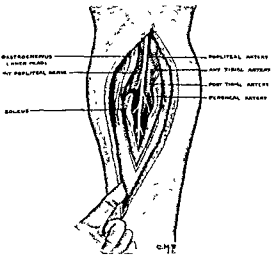

Fig 2230.—Exposure of vessels in popliteal space and back of leg.

If the surgeon desires to expose the popliteal bifurcation, or the origins of the anterior and posterior tibial and peroneal arteries, he can split the soleus on a director (fig. 2230). In this manner an excellent exposure is made of these vessels, and any injury of them can be dealt with, without incurring the great danger of gangrene which is associated with ligation of the popliteal artery itself.

Posterior Tibial Artery.

The *classical method* is another good examination test, but it gives

very poor access to the artery. The leg is flexed and rests on its outer side. A 4-inch incision is made an inch behind and parallel to the inner border of the tibia, down to the gastrocnemius. This is retracted away from the tibia, and the soleus is cut through well away from the inner edge of the tibia. The artery will be found external to the tibialis posticus, and embedded in the transverse intermuscular septum.

In the *modern method*, which gives a far better exposure (fig. 2230), the patient lies prone, with the foot over the end of the table. A long incision is made between the heads of the gastrocnemius and towards the medial side of the tendo Achillis. The short saphenous nerve and vein are seen and hooked aside. The gastrocnemius is now split between its two heads, and these are widely retracted. A finger is then pushed up under the soleus, and this is also split down its middle, and retracted. An excellent exposure is thus obtained of the posterior tibial vessels, as well as of the peroneal artery.

Anterior Tibial Artery.

The line of the artery is from a point midway between the head of the fibula and the external tuberosity of the tibia, to the mid-point between the two malleoli in front of the ankle. An incision is made along the line of the artery, which in its upper part lies deeply between the tibialis anticus, clothing the tibia, and the extensor longus digitorum, covering the fibula. Strong retraction of these muscles brings the artery into view. Lower down, the artery becomes superficial and can be reached with ease.

Gluteal and Sciatic Arteries.

Wounds of the buttock produce a hæmatoma under the gluteus maximus, and nothing short of a very free exposure will prove satisfactory in dealing with them. With the patient lying prone, a curved incision is made a little below the iliac crest and down towards the great trochanter. This exposes the dense gluteal aponeurosis, which is divided in the line of the skin incision. In this manner, the gluteus maximus is freed, and can be retracted well back, providing an excellent exposure of the pyriformis muscle, and of the gluteal and sciatic vessels and nerves. The gluteal artery is found above this muscle at its emergence from the great sciatic notch, while the sciatic artery is below it, running down a little distance medial to the sciatic nerve.

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PART XXII

LYMPHATIC SYSTEM

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by

RODNEY MAINGOT

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LYMPHATIC SYSTEM

CHAPTER I

Affections of the Lymphatic Vessels

by

Rodney Maingot

In this chapter the following conditions will be discussed:

(A) Injuries of the Lymphatic Vessels and of the Thoracic Duct.

(B) Inflammations of the Lymphatic Vessels—Lymphangitis:
  (1) Acute; (2) Chronic.

(C) New Growths of the Lymphatic Vessels—Lymphangiomata:
  (1) Capillary; (2) Cavernous; (3) Cystic Hygromata.

INJURIES OF THE LYMPHATIC VESSELS

With every surgical incision some lymphatic vessels are necessarily severed, but there is no noticeable discharge of lymph unless a large vessel or lymphatic trunk, such as the thoracic duct, is cut, a lymphangioma or cyst is incised, or an incision is made into an area where there is marked lymphatic obstruction, such as may occur in cases of elephantiasis.

Except in cases of an ordinary skin incision, there will, in each of the instances mentioned, be a discharge of lymph (*lymphorrhœa*), and where the thoracic duct is severed a *lymphatic fistula* may result. In the majority of cases, however, there is a cessation of the discharge as soon as healing of the wound takes place and new lymphatic vessels form.

INJURIES OF THE THORACIC DUCT

(A) *In the Neck*

The thoracic duct may terminate in several branches which open separately into the internal jugular and subclavian veins. When in the form of a single trunk, the duct will often be seen to enter the postero-lateral aspect of the union of these two large veins on the left side of the neck (fig. 2231). The right lymphatic duct may end as a single trunk and join the right subclavian vein, or it may take the form of several branches which open separately into the internal jugular and right subclavian veins. Division of the right lymphatic duct may occur during the performance of operations upon the neck, but is, as a rule, of no particular consequence.

Causes of Injury. These fall into four groups:

(1) Operations upon the neck: (*a*) for tuberculous glands; (*b*) for malignant glands; (*c*) for substernal goitre; (*d*) for thymic tumours; (*e*) for cystic hygromata; and (*f*) for phrenicectomy.

(2) Gunshot wounds, stabs, rapier thrusts, etc.

(3) Fractures of the sternum or clavicle.

(4) Compression or erosion due to growth.

Results of Injury. Following rupture or division of the thoracic duct in the neck there is a free discharge of clear limpid or milky fluid

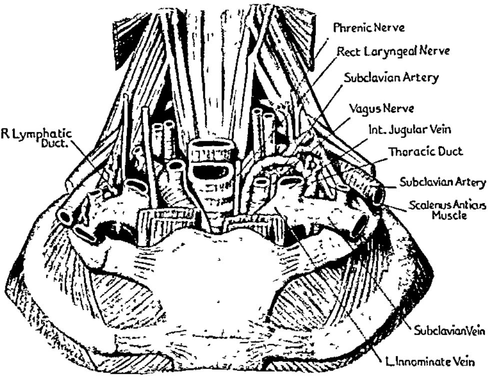

Fig. 2231.—The relations of the thoracic duct and of the right lymphatic duct in the root of the neck.

—chylorrhœa. Where the thoracic duct is present as a single trunk and this is severed, the results may be disastrous through loss of chyle, and may cause the patient to die from inanition. In cases of profuse chylorrhœa following such an accident there is marked thirst, progressive loss of strength, rapid emaciation, cyanosis and collapse, sometimes leading to an early fatal issue unless prompt and effective measures are taken to arrest the flow of lymph. Where the duct is composed of several branches and *all* of these are inadvertently cut, the same grave results will inevitably follow. Such an occurrence is, however, happily very rare, the more frequent accident being the severance of one or two of the main branches, causing a discharge which soon ceases

without producing much, if any, ill effect. If such an accident passes undetected at the time of operation it will later be evidenced by one of two *conditions*: (1) *A gradually increasing cystic swelling in the neck*; or (2) a lymphatic fistula accompanied by a profuse discharge of milky chyle.

Treatment. This depends upon whether the injury is recent or old.

(1) When the injury is recognised *during the performance of an operation*, both ends of the duct should be identified and ligatured. Likewise, if more than one large lymphatic vessel is cut, the individual ends of each should be picked up and tied. The surgeon who is anatomically minded will realise that ligature of the distal end of the duct is unnecessary, as the presence of valves at its termination will prevent any possibility of reflux. Theoretically, the ideal measure is to isolate the distal end of the duct and to anastomose it to the cut end of the external jugular vein or to the side of some large adjacent vein ; but in practice this operation, although it has been successfully performed on a few occasions, is often rendered difficult or even impossible owing to the small calibre of the thoracic duct.

(2) When a cystic swelling appears *subsequent to an operation* upon the lower part of the neck, and probing shows its contents to be chylous in nature, there are two methods which are commonly employed for arresting the flow of chyle. In the first, the patient is given large quantities of cream for a few days prior to operation, so that when the wound is reopened the welling up of white viscous chyle from the severed end of the duct will indicate the point of severance and permit of its being clipped and tied. The wound is then partly closed and drained. By the second method, the wound is reopened and tightly packed with gauze soaked in glycerine, firm pressure being applied to the area by means of a stout sorbo pad over a thick dressing of gamgee tissue.

(3) When a *lymphatic fistula* follows an operation upon the neck, the wound should be reopened and packed, and pressure applied.

(B) *In the Thorax*

Macnab and Scarlett have given the following classification of the *causes of chylothorax :*

(1) *Trauma.*

- (*a*) External violence :
  - (i) Closed trauma (there being no external wound or fracture), e.g. by falls from a height, run-over accidents, crushing between cars, buffer accidents, a weight falling upon the back, etc.
  - (ii) Trauma with fractured ribs, clavicle or vertebræ.

(b) Operative wound:
(i) Duct completely severed.
(ii) One or more terminals cut.
(c) Gunshot wound.
(d) Stab wounds, self-inflicted or otherwise.

(2) *New Growths and Granulomata*, e.g. carcinomata, lymphosarcomata, or tuberculous mediastinal glands, producing obstruction of the duct by pressure from without and leading to rupture.

(3) *Thrombosis of the Left Subclavian Vein.*
(4) *New Growths of the Duct itself.*
(5) *Perforating Lymphangitis.*
(6) *Aneurysm of the Duct.*
(7) *Cirrhosis of the Liver.*
(8) *Filariasis.*

In a general way it may be stated that roughly half the cases of chylothorax result from spontaneous rupture of the thoracic duct following obstruction or compression by new growth or tuberculous disease of the mediastinal glands, and the other half from trauma.

TRAUMATIC CHYLOTHORAX

This is a rare condition, there being less than 100 cases recorded to date. It is associated with the high mortality of 50 per cent, the survival of the remainder being attributable to the existence of a very liberal system of collateral vessels and anastomoses throughout the entire course of the duct. In most instances rupture occurs on the right side, as the lower portion of the duct lies on this side of the body, being shielded on the left by the cushion of the aorta.

Clinical Features. On admission the patient is found to be suffering from shock, generally as a result of some injury to the back. He will gradually recover from the initial shock, and for a period varying from 2–6 days will appear to be progressing favourably, although hunger and thirst may be unduly pronounced. There are no characteristic early signs apart from those which are the direct outcome of the accident. At the end of a few days, however, there is nearly always a most dramatic change in his condition, and this usually coincides with the appearance of the chylothorax. The patient suddenly sinks back in bed in a semi-conscious state, gasping for breath and drenched in a profuse cold sweat. He may be pallid or slate-blue in colour, and lies motionless with half-closed glassy eyes. The pulse is racing, thready and weak, and the urine is scanty and loaded with acetone bodies.

On examination of the chest, signs of a pleural effusion, usually

affecting the right side, will be found. When this fluid is aspirated to relieve distress, its creamy character will at once proclaim the diagnosis. The frequent tappings of the chest and the withdrawal of large quantities of milky lymph will for a time add considerably to the comfort of the patient, and effect some improvement in his general condition. If, after a few days, the fluid continues to accumulate, the prognosis becomes exceedingly grave, and in the majority of cases hopeless. There will soon be marked progressive loss of weight, profound weakness, and insatiable thirst, all directly due to the lymphorrhœa. These cases become gradually worse and eventually die of exhaustion. If, on the other hand, the amount of pleural fluid which has to be withdrawn steadily decreases and the patient's general condition improves, it is clear that the flow of lymph is being diverted through other channels, that the breach in the thoracic duct is becoming closed, and that a normal flow of chyle is being re-established.

It will thus be found that in these cases of traumatic chylothorax it is often possible to recognise four distinct phases in the clinical picture: (1) The stage of *shock*, as a result of the accident; (2) The stage of *recovery* from shock—the latent period; (3) The stage of profound *collapse;* and (4) The stage of either *asthenia* and *inanition* leading to *death*, or of *recovery*. The latent period, i.e. the time which elapses between the initial injury and the onset of sudden collapse and pleural effusion—usually 2–6 days—is the most characteristic feature in the clinical history. It may be noted that before the fluid in the chest is aspirated, a provisional diagnosis of hæmatothorax is frequently made.

It is a remarkable and interesting fact that the effusion never occurs immediately after the injury. According to Macnab and Scarlett the abrupt onset and the gravity of the symptoms suggest a condition of anaphylactic shock. They write:

> "In our opinion the resemblance between this condition and that developing as the result of spontaneous pneumothorax is suggestive. One could account for the degree of shock on the basis of an abrupt disturbance of the pressure relations existing in the thoracic cavity with partial collapse of the lung due to the sudden release into the pleural space of chyle which previously had been protected in the parapleural tissues."

Prognosis. As already stated, in these cases the chances of recovery and of death are about equal. There are two causes of death:

(1) *Immediate*, due to suffocation and heart failure; and (2) *Remote*, the result of inanition through the loss of nutrient material normally carried to the subclavian vein by the thoracic duct.

(*b*) Operative wound:
(i) Duct completely severed.
(ii) One or more terminals cut.
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(1) *Immediate,* due to suffocation and heart failure; and (2) *Remote,* the result of inanition through the loss of nutrient material normally carried to the subclavian vein by the thoracic duct.

Treatment. This may be briefly outlined as follows:

(1) Treatment of shock and of any injury, e.g. fracture of the spine; (2) Repeated aspiration for the relief of distressing symptoms such as dyspnœa. Aspiration will usually be necessary twice a day owing to the large amount of fluid which rapidly accumulates in the chest; (3) A quantity of the aspirated chyle may be diluted and injected intravenously by the slow drip method in order to combat the rapid emaciation which accompanies the chylorrhœa, but this measure is of doubtful value; (4) Large quantities of fluid rich in carbohydrates should be given, but fats are forbidden; and (5) Thorocotomy is sometimes performed to create a continuous atmospheric pressure; it may also be indicated when aspiration would appear to be necessary more than two or three times a day in order to relieve the distressing symptoms of suffocation. If thorocotomy is performed, any clots or conglomerations of sticky gelatinous chyle must be removed at the same time.

The success of treatment depends almost entirely upon there being a sufficient number of collateral channels in the course of the duct in the thorax. If, happily, the collateral circulation at length becomes established, recovery of the patient is almost assured.

(C) *In the Abdomen*

The *causes of chylous ascites* and of retroperitoneal extravasation of chyle are similar to those already enumerated under chylothorax, and may be classified as follows:

(1) *Congenital,* e.g. distension and rupture of the thoracic duct proximal to a stricture.

(2) *Acquired:*

- (*a*) Trauma, such as may result from run-over accidents, fractures of the spine, acute hyperextension of the infant's trunk during parturition, gunshot wounds, stabs, or following excision of large retroperitoneal tumours, etc.
- (*b*) Rupture due to over-distension, as the result of compression or blockage of the duct by neoplastic tumours, tuberculous glands, or lymphadenomatous masses.
- (*c*) Diseases of the duct itself, e.g. cancer or aneurysm.
- (*d*) Filaria.
- (*e*) Secondary to cirrhosis of the liver, cardiac disease, nephritis, or amyloid disease.

Clinical Features. In the *congenital* cases difficulty in parturition may be experienced on account of the marked distension of the infant's

abdomen. Wegner, who has reported a case in which the baby presented a sorry spectacle, writes:

"He had the largest abdomen I have ever seen in an infant of his age. He made one think of a toy rubber balloon to which are attached a paper head and dangling paper arms and legs. The scrotum bulged irregularly and was so distended that the penis was buried by it. It contained fluid which was easily forced into the abdominal cavity. The abdominal walls were tense; the cavity was filled with *fluid. The enlargement was symmetrical. The intra-abdominal* pressure had forced the diaphragm upward, displacing the lungs and heart, and spreading the lower ribs. *Excepting the abnormalities described, and the fact that the child* was quite pale, he seemed to be normal."

In the *acquired* cases there is a gradually increasing distension following some injury to the lower portion of the spine or the abdomen,

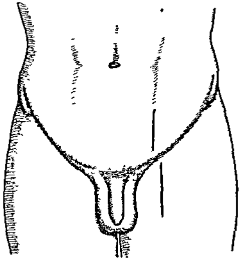

Fig. 2232.—Venous peritoneal anastomosis. Position of the incisions

or associated with some chronic intra-abdominal disease such as lymphadenoma. When the abdomen is tapped, the milky nature of the fluid will establish a diagnosis of chylous ascites. In certain cases it may be of academic interest to submit the ascitic fluid to cytological and chemical investigation in order to determine whether the condition present is one of true chylous or pseudo-chylous ascites (Quincke), but the findings will have no influence upon the method of treatment to be adopted.

On paracentesis, several pints or even gallons of chyle will be withdrawn from the abdomen, after which, in cases due to growth or granulomatous masses, tumours may be felt on examination of the abdomen. The fluid rapidly re-accumulates, re-distending the abdomen, bulging the flanks, and pushing up the diaphragm so that the heart's action is embarrassed and there is difficulty in breathing. Owing to the repeated tappings which are necessary to relieve this distension and the

patient's distress, there is progressive loss of weight, asthenia, dehydration, and pronounced and unquenchable thirst. Most of these cases will die of inanition, peritonitis, or some intercurrent disease such as pneumonia. Occasionally, however, and especially in those cases which are the result of trauma, spontaneous recovery may take place if the flow of chyle becomes re-established through the collateral channels.

Treatment. This depends upon the nature of the cause, but will usually comprise tapping the abdomen. Permanent drainage with a

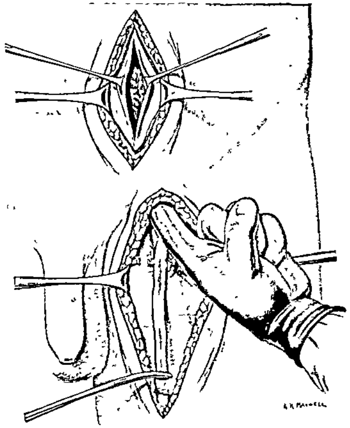

Fig 2233.—Venous peritoneal anastomosis. The vein has been freed, and the subcutaneous tunnel prepared. Through the upper incision the peritoneum has been opened so that chylous fluid may be withdrawn by suction prior to anastomosis.

Southey tube, and laparotomy followed by washing out the peritoneum, have been practised, but are of no permanent value. In congenital chylous ascites, however, or where the patient has received some injury from which he is slowly recovering but which has caused intraperitoneal rupture of the duct, the establishment of *venous peritoneal anastomosis* is well worth a trial. This is performed as follows: Assuming that the operation is being undertaken on the left side, a small low-placed vertical incision is made at the outer border of the left rectus muscle, all tissues being divided down to the parietal peritoneum, which is then picked up and incised for a distance of one

inch, each edge of the peritoneum then being clipped with a hæmostat. Another incision, commencing one inch below the inner third of the inguinal ligament and extending downwards for three inches or more on the antero-medial aspect of the left thigh, is made over the course of the internal saphenous vein (see fig. 2232). This vein is identified, isolated from the saphenous opening, and freed downwards for a distance of about three to three and a half inches, its tributaries being divided close to the vein and ligatured with fine plain catgut. The lowest

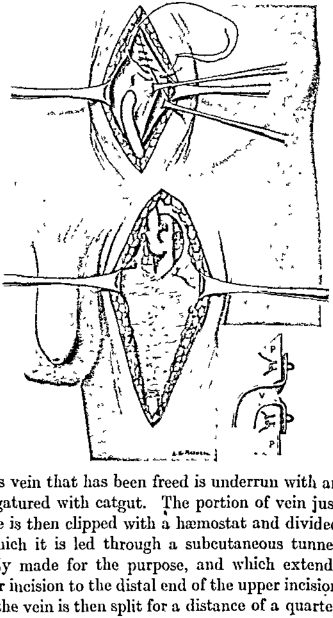

Fig 2234.—VENOUS PERITONEAL ANASTOMOSIS. THE OPERATION IS NEARLY COMPLETED, AND THE PARIETAL PERITONEUM IS BEING SUTURED.

(*Inset*) CROSS SECTION OF THE VEIN, SHOWING METHOD OF ANCHORING THE CUT EDGES OF THE VEIN TO THE PERITONEUM

portion of the saphenous vein that has been freed is underrun with an aneurysm needle and ligatured with catgut. The portion of vein just proximal to this ligature is then clipped with a hæmostat and divided with a scalpel, after which it is led through a subcutaneous tunnel which has been specially made for the purpose, and which extends from the top of the lower incision to the distal end of the upper incision (fig. 2233). The end of the vein is then split for a distance of a quarter of an inch and drawn through a small opening in the peritoneum medial to the original incision, and the two portions of the divided vein are stitched with fine catgut to the parietal peritoneum in the manner

depicted in figure 2234. Both parietal and femoral incisions are then closed in the usual manner.

The success of this operation, which may at times be spectacular, depends upon scrupulous attention to many minor but important points in technique. Thus, the portion of the saphenous vein selected must not be bruised or damaged in any way, either with the fingers or with instruments, during the process of freeing it from the thigh, as this will lead to endophlebitis with subsequent clotting and obliteration of the lumen of the vein; it must not be kinked at its point of junction with the femoral vein; there must be no undue tension or stretching of the segment of vein between its two points of attachment; chilling of the vein must be prevented by playing a jet of warm saline on it during the whole course of the operation; and, finally, the tunnel which is made in the subcutaneous tissues must be of dimensions adequate to accommodate the vein without unduly compressing it. If these precautions are observed, the operation should not infrequently prove successful.

INFLAMMATIONS OF THE LYMPHATIC VESSELS—LYMPHANGITIS

Infection of the lymph vessels may be acute or chronic.

(1) *Acute Lymphangitis.*

This is an acute inflammation of the lymphatic vessels due to infection with pyogenic micro-organisms, usually streptococci, although staphylococci or mixed infections or their toxins are sometimes responsible. The invading organisms usually gain entrance to the lymphatic vessels through pricks or abrasions in the skin or mucous membrane, or through small cuts, dirty contused wounds, infected sores, furuncles, etc. In a number of cases the primary breach in the skin is completely healed, covered by a scab, or difficult to identify, although at other times the focus of infection is obvious.

"Acute lymphangitis is characterised by a tenderness along the course of the main lymphatic trunks situated between the infected wound and the nearest group of lymph nodes. In severe cases a red line will be seen, in the case of the upper limb running along the front of the forearm and upper arm to terminate in the axilla. The red line may not, except perhaps in the most severe cases, be continuous, but only seen as an interrupted line and sometimes as a diffuse one. The actual cause of this lymphangitis is not clear. Infection may spread from the primary lesion to the lymphatic gland by an embolus, the lymphatic vessels themselves escaping disease, but in those cases where lymphangitis is present, inflammation of the walls of the lymphatic vessels must be due either to the presence of organisms actually growing in the lymphatic vessels or due to the irritation by exotoxins manufactured at the site of the primary lesion. It seems reasonable to suppose that the former is the case, the organisms growing along the main lymphatic trunks by a process of permeation similar to that of cancer cells,

differing, however, in the extreme speed with which pyogenic organisms multiply. This statement is borne out by the frequent occurrence of abscesses in the cellular tissue along the course of the main lymphatic trunk. The red line is, in fact, due to peri-lymphangitis or inflammation of the cellular tissue *in immediate contact* with the lymphatics. It is probable that when a red line is present, whether due to exotoxins carried by the lymphatic stream or to the actual presence of organisms growing along the lymphatics, the lymphatic vessel itself becomes occluded, and this adds to the inflammatory œdema which is a characteristic feature of the condition. Localised abscesses in the peri-lymphatic cellular tissue are due to leakage of the organisms from the lymphatic wall at a place where the inflammation due to their presence has destroyed it." (Harold Edwards.)

The effects of the infection naturally depend upon the virulence of the infecting agent and the resistance of the patient. The majority of cases rapidly respond to treatment, but a few may develop acute fulminating septicæmia, particularly patients who are very debilitated and those who are suffering from diabetes, chronic nephritis, or tuberculosis. General or constitutional disturbances may be absent or negligible, but where the disease is eager in its course the patient will complain of shivering attacks, a burning pain in the affected area profound depression, intense headache, anorexia, nausea and vomiting The danger signals are a rapidly mounting temperature, a running pulse, a flushed face with bright attentive eyes, dry parched lips and tongue, and excitable speech, together with a rapid spread of the local infection, leading in some cases to delirium, collapse, coma, and eventually to death.

Treatment. As every patient with acute lymphangitis may possibly develop septicæmia, a serious view must be taken of each individual case, and treatment be instituted at once on the following lines:

If the primary focus of infection is limited to a *small* circumscribed area, it may be ignored, excised or cauterised. If, however, there is an *extensive* septic area, it is best left severely alone after free painting with a strong antiseptic solution, such as tinct. metaphen (Abbott), or dressing with a reliable antiseptic ointment made up as follows:

Phenol	1 per cent.
Salicylic acid	2 per cent.
Camphor	3 per cent.
Pure lanoline to ½ oz.	

If a limb is affected it must be kept completely at rest, splinted and elevated, the most comfortable splint being of the gutter type made of plaster-of-Paris. If the lymphangitis is limited to a small area, say, to that of a finger or the dorsum of the hand, strapping firmly and evenly with elastoplast—the occlusive form of treatment—is well

worthy of a trial. Usually, however, large hot compresses of magnesium sulphate in glycerine (20 per cent) are applied, not only to the area immediately affected but to the part well above and below the lesion. These compresses should be changed frequently, and be covered with thick layers of gamgee tissue over which jaconet is placed, and the whole dressing lightly bandaged. A pad of antiphlogistine, $\frac{1}{4}$-inch thick and of appropriate size, is one of the best applications. Raised to a temperature as high as can be borne with comfort, it retains its heat for a considerable time and need not be changed more than twice a day.

Under no circumstances should incisions be made into areas of lymphangitis or subcutaneous cellulitis unless it is clear that there are definite local collections of pus which require to be evacuated. The making of multiple small incisions into an area of spreading infection in the skin is to be deprecated, as these incisions have no effect in arresting the progress of the disease, the drainage afforded is minimal, and the natural barriers to the infection may be broken down, leading to the entry of organisms into the general circulation.

As the invading organism is nearly always the streptococcus, *polyvalent anti-streptococcal serum and/or anti-scarlatina serum* should be injected. The initial dose of either of these sera should always be large. It is far better to inject a total amount of 50 cc. of polyvalent anti-streptococcal serum intramuscularly, or intravenously (but very slowly) diluted with one pint of normal saline, or 30 cc. of anti-scarlatina serum similarly diluted if given intravenously, than to give, say, 10 cc. daily for 5–6 days. Daily intravenous injections of hydrarg. perchlor., $\frac{1}{32}$–$\frac{1}{16}$ gr., of arsenic in the form of N.A.B., or of mercurochrome for two to four doses may be tried, but in my experience they have not proved to be of much value in cases of frank septicæmia. During recent months prontosil (Bayer) has been extensively used in the treatment of streptococcal infections, and, on the whole, the results obtained appear to be encouraging. This substance is available in three forms: (1) Prontosil soluble (for injection); (2) prontosil red tablets; and (3) prontosil album (the sulphonamide preparation). All are closely interrelated chemically, the first two being azo dye compounds. They have *in vivo* action against hæmolytic streptococcal, and possibly other, infections not yet fully explained. Reference to their clinical use may be found in the articles by Leonard Colebrook and others in the *Lancet* of June 6th, 1936, and elsewhere. According to the severity of the condition, the patient should receive daily intramuscular injections of up to 40 cc. (in exceptionally severe cases more) spread over twenty-four hours. The injections are continued

until the temperature falls and the pulse-rate approaches normal Treatment may conveniently be continued with tablets, 1–2 well chewed up and taken with plenty of fluid three times a day, for 4–5 days after the temperature has fallen to normal. The prontosil red tablets, which were originally used in Dr. Colebrook's work, may be replaced by prontosil album, which is non-staining. At present, however, clinical evidence is not available to enable us to say which of these two oral drugs is the more satisfactory. Cyanosis may follow the use of prontosil in cases of renal or hepatic insufficiency.

In grave cases the patient should be ordered large quantities of fluids, i.e. 6–10 pints each day, and in certain instances this should be supplemented by intravenous or rectal salines. An easily assimilated diet rich in vitamins and sugar is also prescribed.

When the acute affection has subsided, the anæmia which may result may be counteracted by means of adequate doses of ferri et ammon. cit., e.g. 30–45 grs. t.d.s., and the healing of the drainage wound (if any) accelerated by a course of artificial sunlight. Radiostoleum or some similar concentrated vitamin preparation may be given during the acute stages, and may be continued during the period of convalescence. When healing has occurred, it is essential that the patient should be sent away for convalescence before resuming work.

(2) *Chronic Lymphangitis.*

Chronic simple (pyogenic) lymphangitis is commonly a sequel to an acute attack. In such cases the lymphatic vessels may feel like long thin cords running under the skin. There may also be an associated œdema of the affected part.

Syphilitic lymphangitis is well seen in cases of Hunterian chancre, where the indurated lymphatic strands can be seen and felt travelling from the sore on the penis to the enlarged, shotty inguinal glands.

Tuberculous lymphangitis is occasionally seen in association with tuberculous ulcers of the skin. The infection spreads along the lymphatic vessels which become hard, swollen, beaded, and somewhat tender. The nodules which form here and there in the line of the involved lymphatics may soften, break down, and discharge thin pus, giving rise to a chronic ulcer which has undermined edges and a base lined with pale pink watery granulation tissue. The skin surrounding these ulcers is often involved in the infection, and presents a shiny purple- or mauve-coloured appearance. Very often wide excision with the cautery is the only successful treatment for such cases.

INNOCENT NEW GROWTHS OF THE LYMPHATIC VESSELS—LYMPHANGIOMATA

These tumours somewhat resemble hæmangiomata, except that their channels and spaces contain lymph instead of blood. They are believed to be congenital in origin and to arise in defects in the development of the lymphatic vascular system.

Lymphangiectasis is a term applied to those cases in which the lymphatic vessels become dilated following injury or inflammation, and where their continuity with the normal lymphatic circulation persists. A lymphangioma, on the other hand, is the result of a new formation. Sometimes the two conditions develop side by side. There are three varieties of lymphangioma: (1) Capillary or nævoid; (2) Cavernous; and (3) Cystic hygroma.

Capillary or Nævoid Lymphangiomata. These are usually small, pink or yellowish-brown, cystic, circumscribed swellings, and are in many respects similar to the nævi which occur on the skin and mucous membrane. In certain cases, however, they may be diffuse, as, for instance, in the tongue (see page 3018). These lymphatic tumours are most frequently seen on the lips (*macrocheilia*), cheeks, tongue (*macroglossia*), skin, subcutaneous tissues, in or between muscles, in the viscera, etc. In some instances there may be a combination of lymphangiomatous and hæmangiomatous tissues in a single tumour. Histologically, they are composed of a complicated system of anastomosing channels or spaces, lined by flattened or cubical endothelium and filled with clear limpid fluid containing a few lymphocytes. The supporting stroma is composed of fibro-fatty tissue. If small, the tumours should be treated by excision or cauterisation. If diffuse, they are often resistant to treatment and tend to ulcerate and produce a great deal of pain. Cure may sometimes be effected by means of radium, X-rays, or electrolysis.

Cavernous Lymphangiomata. These innocent endothelial growths closely resemble cavernous nævi, and usually affect the subcutaneous tissues, the mucous membrane, the prepuce, or the intermuscular septa, their treatment being in every respect similar to that of cavernous nævi.

Cystic Hygromata. These are rare tumours, generally seen before the age of 10, although adult cases have been reported. Herzfeld considers that they are the commonest lesion observed *at birth.* They are probably sequestrations of lymphatic tissue (due to some developmental fault) which have maintained the power of persistent but irregular growth. Those that occur in the neck usually

have their origin in the vestigial rests of the large jugular sacs. They are mostly amalgamations of multilocular, thin-walled cysts, lined with a single layer of endothelium having the appearance of a mosaic, contain clear serous fluid, and possess a remarkable power of growth. The following is the order of frequency in which they appear in different parts of the body: the neck, the axilla, the pectoral region, the sacral region, the retroperitoneal tissues, the great omentum, between the layers of the mesosigmoid, the groin, the floor of the mouth, the liver, and the suprarenal gland.

When occurring in the *neck*, such a tumour usually arises under the sterno-mastoid muscle as a multilocular cystic swelling which protrudes into the anterior and posterior triangles and sometimes extends underneath the clavicle and downwards into the axilla. The individual cysts, surrounded by a supporting framework of fibro-fatty tissue which binds them together, are also adherent to neighbouring muscles, to vascular sheaths, to large nerves, and even to the skin when following an inflammatory attack.

In certain instances the tumours may be unilocular, when they are termed *solitary lymphatic cysts*. These cysts, which also are thin-walled, lined with a single layer of flattened endothelium, and which contain clear limpid fluid, are chiefly found in the neck where they are seen as smooth, fluctuating, elastic, slow-growing, globular swellings. They may lie behind the belly of the sterno-mastoid muscle or in the posterior triangle of the neck above the clavicle. *Cystic lymphangiomata of the mesentery* are undoubtedly among the rarest tumours encountered in the field of general surgery. Parsons was able to find approximately 500 cases of mesenteric cysts, but only 10 true lymphangiomata, and he has contributed to the literature a detailed report of a case which occurred in his practice, together with a full bibliography of the condition (*Ann. Surg.*, April 1936, 520, 595).

A *cystic hygroma in the neck* must be distinguished from: (1) Lipoma; (2) branchial cyst; (3) aberrant lateral adenoma of the thyroid; (4) angiosarcoma; (5) aneurysm; and (6) tuberculous abscess.

Treatment. In view of the tendency to spontaneous recession which all these tumours possess, surgical treatment is never called for immediately. The *solitary cysts* should either be excised, or their contents aspirated and the cyst cavity injected with 3–5 cc. of quinine-urethane or lithocaine to effect cure by a process of slow fibrosis and cohesion of the walls of the cyst. The *multilocular cysts* are exceedingly difficult to excise completely, as they are so firmly adherent to important

structures in the neck, such as the large vessels and nerve trunks. If small and easily accessible, they should be dissected out; but if large and deeply penetrating, treatment by means of X-rays or radium is to be preferred to a partial removal of the tumour, as dangerous septic complications may follow the latter attempt. In those cases where at operation it is found impossible to dissect completely the whole of the ramification of the cyst-like processes which have extended far beyond the operation area, the wound should be closed, drainage instituted, and, when healing is nearly established, the parts should be subjected to a course of X-ray treatment.

As an alternative to X-ray or radium treatment in cases where excision is impossible, Harrower's method of repeated injection of the cystic mass with sodium morrhuate may be recommended.

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CHAPTER II

Inflammation of the Lymphatic Glands—Lymphadenitis

by

Rodney Maingot

(A) Acute Lymphadenitis.
(B) Chronic Lymphadenitis:
(1) Simple; (2) Syphilitic; (3) Tuberculous.

ACUTE LYMPHADENITIS

Acute lymphadenitis is inflammation of the lymphatic glands caused by organisms reaching them via the lymphatic vessels from the skin or mucous membrane. The infecting organism is usually pyogenic, but at times B. mallei, B. anthrax, B. pestis, or Ducrey's bacillus may be responsible.

In all cases the area which drains into the lymphatic glands should be very carefully examined for cuts, scabs, sores, infected blebs, etc. The glands are enlarged, elastic, painful and congested, later becoming adherent to one another and to neighbouring tissues, while the overlying skin is often œdematous and red. As the glands enlarge in size they form one indefinite confluent tumour. With removal or with appropriate treatment of the primary focus of infection and local treatment of the affected glands, resolution will frequently occur. Failing this, the glands may become chronically infected and enlarged, in which case —particularly when those in the neck are concerned—the tubercle bacillus is likely to become an additional infecting agent. On the other hand, the glands may soften and suppurate, forming a large abscess which may spread widely in the surrounding tissues or discharge on to the surface. The common symptoms of toxæmia, such as malaise, fever, lack of appetite, etc., may or may not be present. In certain instances the general disturbance may be very marked, suggesting that the infecting organisms have entered the blood stream giving rise to a widespread septicæmia.

The different groups of glands which are most commonly infected are the following: (1) The superficial glands of the head and neck;

(2) the deep cervical glands; (3) the lateral pharyngeal glands; (4) the glands of the upper extremity, sub-divided into the epitrochlear, and the axillary and pectoral groups; (5) the glands of the lower extremity—the popliteal, the inguinal, and the iliac; and (6) the abdominal glands.

The methods of dealing with all acutely infected superficial glands, such as those that may occur in the neck, are in the main similar, and may be briefly outlined as follows:

(1) *Local Treatment.* This consists of attacking, if possible, the primary focus of infection and applying frequent fomentations or antiphlogistine to the affected area until resolution has taken place, or until an abscess has formed and is pointing. This can then be drained through a small judicious incision. Subsequently, a small tube is inserted into the abscess-cavity for the purpose of drainage. After this, hot hypertonic saline (15 per cent) dressings should be used, as it is not advisable to apply antiphlogistine to open wounds. In those cases in which the glands remain enlarged and show no signs of subsiding or of suppurating, it may be well to dissect them out completely, after which the wound is partially closed and drained.

(2) *General Treatment.* The patient is put to bed, and the affected part is splinted or otherwise immobilised as completely as possible. The bowels are made to act by means of saline aperients, fluids are given in abundance, and a diet of ample vitamin content is prescribed.

(3) *Treatment of Suppurating Lymphatic Glands.* This is best considered on a regional basis. A detailed description under five headings is given below:

(*a*) *Uncomplicated Cervical Abscesses.* These abscesses are nearly always secondary to some local infection in the skin, such as a boil in the neck or face, but occasionally they may result from infection from the lips, tonsils or gums. In dealing with such cases it is best to delay operation until the centre of the swelling is soft or until the overlying skin becomes œdematous. A small incision is made over the most prominent part of the swelling, a pair of sinus forceps is thrust into the abscess-cavity, a tube is inserted (and fixed into position with a single stitch), and fomentations are then applied four-hourly. The three conditions which most closely simulate an acute cervical abscess are: (i) infected branchial cyst; (ii) infected cystic hygroma; and (iii) infected thyroglossal cyst.

(*b*) *Submaxillary Glands.* Suppuration is comparatively common in this site, and frequently results from an infected tooth socket. The enlarged glands form a tumour in the region of the submaxillary salivary gland which, with the aid of fomentations, will slowly soften and break through the deep cervical fascia to present a fluctuating swelling. As soon as this is detected, it should be evacuated by Hilton's method. There is no danger of damaging the facial artery provided the incision is a small one and is made over the point of maximum swelling. A

drainage-tube is passed into the wound and stitched to the edges of the skin. This tube is removed in two or three days, after which rapid healing takes place.

(c) *Axillary Abscess.* An abscess in the axilla must be opened and drained without delay, as the pus tends to travel along the path of the nerve trunks into the neck. The site of the incision depends upon the spot at which the abscess points, but as in the average case the abscess lies under the pectoralis major it is best to make an incision about two inches long, just below the fold of this muscle in its upper part. Through this incision a pair of sinus forceps or a hæmostat is thrust upwards and inwards, and the blades are gently opened. A finger inserted through the incision breaks down any loculi in the abscess-cavity. Drainage is provided. In certain cases of long-standing inflammatory enlargement of the glands lying under the pectoralis major, associated with marked constitutional symptoms and failing to subside under prolonged local treatment, it is often advisable to cut down upon and remove the glands through an incision placed just below the fold of the muscle.

(d) *Abscess in the Groin.* This is nearly always secondary to infection of the genitalia, of the anal region, or of an area of skin in the lower extremity (commonly the foot), and should be opened by a vertical incision. Where acutely infected glands in the inguinal region, as elsewhere, show no signs either of resolution or of frank suppuration after a thorough course of local treatment, they should be dissected out, and after every bleeding point has been ligated, the wound should be lightly smeared with B.I.P.P. and partially closed (with drainage).

(e) *Suppuration of the External Iliac Glands.* These receive the efferent lymphatics from the inguinal group of glands which normally drain the lower limb, genitals and perineum, and occasionally become infected without there being much evidence of the superficial or sub-inguinal group being first involved. When they are extensively diseased they may form a large tender mass above the inguinal ligament, which, when on the right side, may closely simulate an appendix abscess, and when on the left, an abscess in connection with a perforated diverticulum of the sigmoid colon. In the female, inflammation of these glands may resemble a severe case of parametritis. When suppuration is extensive, a tender mass may be made out above or below the inguinal ligament, associated with considerable fixation and induration. These cases should be put to bed, and, after treatment has been directed to the primary source of the infection, fomentations should be applied frequently over the affected area until an abscess forms, when this should be opened through a small incision made just above the anterior superior iliac spine, care being taken to avoid opening the peritoneal cavity. Where the inflammatory mass shows no signs of subsiding after an adequate course of treatment, it is often best to cut down on the glands, expose them extraperitoneally, and dissect them out completely. The wound is then partially closed, and drainage instituted.

ACUTE ABDOMINAL LYMPHADENITIS

This condition is due to infection of the abdominal lymphatic glands by pyogenic organisms, the infection reaching them from the gut via the lymphatic vessels. It is conceivable, however, that in certain cases the lymph nodes become infected through the blood stream.

Rendle Short in a series of 200 laparotomies was able to determine its incidence at 6 per cent. Acute abdominal lymphadenitis occurs chiefly before the age of 15, and affects the two sexes with equal frequency.

The *signs and symptoms* of this disease in its *acute* form simulate those of acute appendicitis so closely that the two conditions cannot easily be differentiated. The pain usually commences in the region of the umbilicus or epigastrium, and is often accompanied by colicky spasms; the temperature varies from 99°-104° F., and there is a moderately accelerated pulse-rate. There is often nausea, and the patient may vomit once or twice, but vomiting is, as a rule, not a common symptom. The pain eventually settles down in the right iliac fossa or hypogastrium, and is of a dull gnawing or continuous aching character. At other times, however, it ceases as suddenly as it began, only to recur at intervals with equal intensity. On *examination*, a definite area of abdominal tenderness, cutaneous hyperæsthesia, slight muscular spasm, and rigidity can sometimes be made out in the right iliac fossa, usually over McBurney's point. As a rule, no masses are felt, and a rectal examination is negative. A blood count will frequently show a leucocytosis of 12,000 to 18,000 per cubic mm., 80 per cent of the cells being polymorphonuclear.

There is a *chronic* form of the disease in which the patient gives a long history of loss of energy and of weight, and of recurrent short spells of abdominal distress, each culminating in an attack of acute abdominal pain which may last for a few hours or subside with dramatic abruptness, only to return after a brief interval.

The mechanism of the infection is unknown, but one may assume that the portals of entry for the micro-organisms are located in an area of catarrh or in a minute ulcerated patch in the mucous membrane of the lower ileum, cæcum, or appendix. Contaminated food or milk may be a vehicle of infection, whilst intestinal parasites and local trauma of the gut may be predisposing factors.

The following have to be considered in the *differential diagnosis* of the *acute* type: (1) Acute appendicitis; (2) tuberculous mesenteric lymphadenitis; (3) intussusception; (4) inflammation of Meckel's diverticulum; (5) acute pyelonephritis; and (6) acute regional ileitis (Crohn, Ginsburg and Oppenheimer, 1932, *J.A.M.A.*, Vol. 99, 1323).

Treatment. As the condition in its acute form cannot otherwise be distinguished with certainty from acute appendicitis, exploratory laparotomy should be undertaken without delay, and the appendix should in all cases be removed, whether it appears to be diseased or

normal. The manifold enlarged glands, elastic, discrete, swollen, and usually found at the root of the mesentery, along the course of the ileo-colic artery, and in the ileo-cæcal angle, *should not be disturbed*, although it is advisable to remove an easily accessible gland for biopsy. Free peritoneal fluid, which is usually present in excess, should be mopped up or removed by suction.

The *prognosis* following laparotomy and removal of the appendix is very good, and in the majority of cases a complete recovery may be expected in due course. Strömbeck followed up 40 cases which had been operated upon over four years previously, and found that 87 per cent were free from symptoms. He had no operative deaths in his series, and similar satisfactory results are reported by Rendle Short and others.

CHRONIC LYMPHADENITIS

(1) *Chronic Simple Lymphadenitis.*

This condition, which is often mistaken for tuberculous lymphadenitis, is due to an infection of the lymphatic glands with pyogenic micro-organisms. When occurring in the neck it is almost always due to a persistent primary focus of infection in the area drained by the glands. The commonest causes are: (*a*) Oral sepsis (carious teeth, gingivitis, alveolar periostitis, chronic tonsillitis, chronic pharyngitis, etc.); (*b*) lesions of the skin or scalp (eczema, impetigo, pediculosis of the scalp, ulcers, cuts, cracks, fissures, etc.); and (*c*) a preceding acute septic adenitis. Occasionally the infection is hæmatogenous and may occur as a complication of some acute infectious disease. When the glands in the axilla or groin become chronically infected, the primary focus can nearly always be found in the form of infected cuts, ulcers, etc., in the hands, feet, or genital area. Clinically it is often impossible to distinguish the condition from tuberculous lymphadenitis or lymphadenoma, and unless a cure is quickly effected after removing the focus of infection, it may be advisable to remove one of the enlarged glands and submit it to microscopical examination before making a final diagnosis. The glands in chronic simple lymphadenitis are tender, moderately enlarged, rounded, smooth, elastic, firm, and movable under the skin. When peri-adenitis occurs, fixation results, and tuberculosis becomes almost impossible to exclude clinically.

As stated above, treatment consists in removal of or other attention to the primary focus of infection, local applications of heat or counter-irritants to the affected glands, and general tonic treatment. If after a period of, say, three months the glands still persist and show no signs of subsiding, although the primary lesion has resolved

satisfactorily, they should be regarded as tuberculous unless biopsy proves the contrary.

(2) *Syphilitic Lymphadenitis.*

The lymphatic glands become infected in cases of primary syphilis. In cases of genital chancre the glands are discrete, hard and shotty, whereas with extra-genital chancres, such as may occur on the lip, breast, etc., they are usually larger, softer, acutely inflamed and inextricably matted together. In the genital type suppuration does not occur unless secondary infection is superimposed. In secondary syphilis there is usually a general sub-acute adenitis. Tertiary syphilitic lesions of the lymphatic glands are extremely rare, but when they occur they closely resemble "breaking-down" tuberculous glands, in that there is a matting together and softening of the lymph nodes, this being followed by a discharge of grumous material through single or multiple sinuses in the skin. Gummatous adenitis is more often seen in cases of inherited syphilis than in the acquired type. The *treatment* of this condition is discussed under Syphilis (see page 5317).

(3) *Tuberculous Lymphadenitis.*

(*a*) *Ætiology.*

(i) *Age and Sex.* Tuberculous disease of the lymphatic glands may occur at any age, although the majority of cases are seen in children. Females are said to be more frequently infected than males.

(ii) *Heredity.* As far as can be ascertained, there does not appear to be any evidence that the disease is hereditary, but there is no doubt that children of tuberculous parents are more prone to develop it. A clear history of contact with an infected adult is sometimes obtainable.

(iii) *Incidence.* There appear to be a number of reasons why tuberculous lymphadenitis is a disease which is fast decreasing in frequency: 1. The testing and gradual elimination of cows infected with tuberculous disease; 2. the effective pasteurisation of milk; 3. the modern tendency to remove tonsils and adenoids from children of school age, and to treat all septic foci promptly; 4. the isolation of patients, both adults and children, suffering from active phthisis; 5. the existence, nowadays, of better methods of hygiene and a higher standard of living, together with a more careful medical supervision of children by means of clinics, etc.; and 6. the increased resistance of the general population to the disease. This is probably the result of some important but little understood biological phenomenon, but may be in part explained by the prominence now given to a universal and well-organised campaign against the disease.

(*b*) *Bacteriology.*

Like other forms of non-pulmonary tuberculosis, tuberculous lymphadenitis is, in most instances, caused by the bovine type of bacillus, and this is especially the case in children. It is found that the older the patient the more likely he is to become infected by the human rather than by the bovine type; but in both infections the clinical features, the pathological changes in the involved tissues, and the treatment to be adopted are alike.

(*c*) *Pathology.*

The process of the infection and its results may be briefly outlined as follows: The tubercle bacillus travels to the glands by one of two routes—the lymphatic vessels or the blood stream. The bacilli are deposited in a lymphatic gland and light up an irritative and reactionary inflammatory process, with the formation of tubercles or tuberculous follicles. If the disease is overcome, resolution occurs with the production of scar tissue which envelops or replaces the lesion and its causative bacilli. It always leaves its impression upon the gland, however, in the form of fibrous tissue, and in some instances depositions of chalk. When, on the other hand, the disease progresses, caseation takes place, often leading to liquefaction and tuberculous abscess formation, with spread of the infection to other tissues.

The *macroscopical* appearances of a tuberculous gland in the various stages of the infection are usually characteristic. Thus, early in the disease the gland is pale, fleshy, uniformly enlarged, and elastic, while on section no tubercles may at first be made out. Later on, small white or yellow spots, which represent tubercles, will be seen scattered over the surface of the cut gland. At an even later stage, small, discrete, caseous areas may be detected in different portions of the gland. These eventually coalesce until the whole or the greater part is replaced by cheesy material. The capsule of the gland becomes greatly thickened by the fibrous tissue resulting from the inflammation. When the peri-glandular connective tissue becomes involved—peri-adenitis—the glands become adherent to one another and form large ill-defined masses; but when suppuration ensues there is abscess formation and the capsule of the gland may rupture, the contained creamy pus burrowing widely in various directions—along the nerve sheaths, the muscles, and the fascial planes. On the other hand, a local abscess may form, and this, according to its situation, may burst externally on to the skin surface, giving rise to a tuberculous sinus, or into a portion of the gut, into the peritoneal cavity, into a bronchus, etc.

Microscopically, the characteristic lesion is the tubercle, in the centre

of which tubercle bacilli in various stages of degeneration may be seen lying surrounded by endothelial and giant cells (fig. 2235). A little further afield there is an encircling zone of lymphocytes. The endothelial cells themselves are irregular and variable in shape—round, oval, or spindle-shaped—having clear cytoplasm with eccentric, pale-staining nuclei. They are probably derived from the endothelium of the blood-vessels and lymphatic vessels, and also from the fixed connective tissue cells of the part involved. The lymphocytes which occur at the periphery of the follicle are carried there by the blood stream; but in a lymphatic gland which is the seat of tuberculous

Fig. 2235.—MICROSCOPICAL SECTION OF A TUBERCULOUS GLAND.

disease they are probably also derived from the germ centres of the lymph follicles. The giant cells are large and somewhat irregular in shape, with ill-defined margins, and contain near their periphery numerous small, oval or circular nuclei, often arranged in the shape of a horseshoe.

(*d*) *Pathogenesis.*

The effect of the invading tubercle bacilli upon the lymphatic glands depends upon several factors. These are: (i) the virulence of the infection; (ii) the age, nationality, and resisting power of the patient: (iii) the presence or absence of superimposed pyogenic infection; (iv) the particular area affected by the disease; and (v) whether or not the patient contracted the disease in childhood—a fact which will considerably influence the course of a second infection in later life, for if there has been an attack in childhood, the

second infection tends, as a rule, to be milder and more chronic. The disease is commoner among the white than among the coloured races, but when it occurs in the latter it tends to be more lethal. Superimposed infection with pyogenic organisms is greatly to be feared, as it encourages dissemination of the tubercle bacilli and a more active local spread of the disease, abscess formation, marked constitutional symptoms, and other complications, such as the production of fistulæ.

The most important groups of lymphatic glands which may become involved in tuberculosis are: (i) the *cervical*; (ii) the *tracheo-bronchial*; (iii) the *axillary*; (iv) the *inguinal*; and (v) the *abdominal*. An account of the disease as it occurs in each of these groups will now be given.

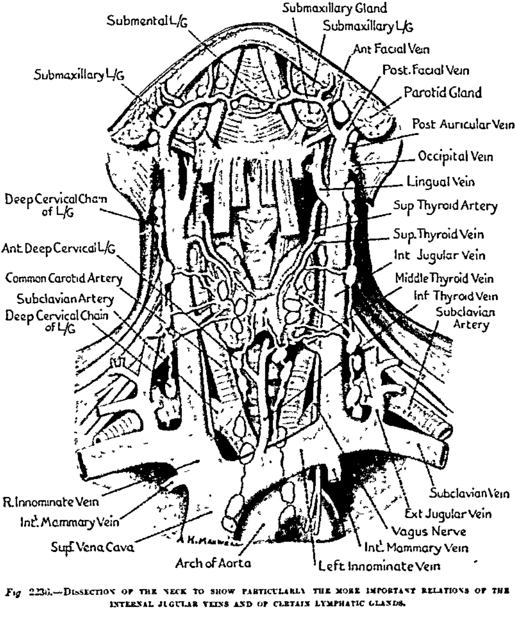


Fig 2236.—Dissection of the neck to show particularly the more important relations of the internal jugular veins and of certain lymphatic glands.

(A) *Tuberculous Glands in the Neck*

Reference to figures 2236, 2277 and 2719 will serve to remind the reader of some of the more important structures and their anatomical relations in the neck, mainly in so far as they concern certain operations for tuberculous lymphadenitis.

The lymphatic glands in the neck are arranged in systems, an upper and a lower circular system, and a vertical system. The majority of the glands in the circular system are superficial, whereas most of those in the vertical system are deep. The upper circular chain surrounds the base of the skull and drains chiefly the face and scalp, the glands in the chain intercommunicating in such a manner that they can pass infection from one gland to another. The groups of glands *in the upper circular system comprise the following:* the submental, the sublingual, the submaxillary, the supra-mandibular or facial, the parotid, the pre-auricular, the mastoid or post-auricular, the occipital, and the retro-pharyngeal. The lower circular chain is poorly represented, there being only a few glands sparsely scattered in the posterior triangle of the neck above the clavicle and in the supra-sternal region.

The vertical system of glands consists of a superficial chain and a deep chain. The chains of superficial glands lie beneath the deep fascia and follow the course of the anterior and external jugular veins. The deep glands, which lie mainly under cover of the sterno-mastoid, are divided on each side of the neck into an upper and a lower group by the line of the omo-hyoid muscle, each of these groups being sub-divided into an anterior and a posterior group. The glands of the upper deep cervical group, and especially those of the anterior division in this group (which are the most important and most frequently infected in the neck) include the *tonsillar or jugulo-digastric gland of Wood. These glands drain the tonsil, the* naso-pharynx, and the greater part of the mouth, and receive efferents from all the glands in the upper circular system. The tonsillar gland is usually constant in position and occupies the triangle formed by the posterior belly of the digastric muscle and the common facial and internal jugular veins. The upper posterior group of deep cervical glands lies behind the internal jugular vein, upon the splenius cervicis and levator scapulæ muscles. The spinal accessory nerve traverses these glands *in its downward course towards the posterior triangle of the neck.* The number of glands in the upper deep cervical group varies from 15–30 nodes. The retro-pharyngeal glands are situated behind the mucous membrane of the posterior wall of the naso-pharynx and anterior to the bodies of the cervical vertebræ. They drain into the upper deep cervical group.

The general flow of lymph in the neck is in a downward direction towards the jugular lymphatic trunks, which empty on the right side into the subclavian vein and on the left side into the thoracic duct. Reference to the Table on page 4125 will show clearly the arrangement of the lymphatic glands in the neck, according as they are grouped under the various systems.

Etiology. As has been stated earlier, the *incidence* of tuberculous glands in the neck is rapidly decreasing for the reasons already detailed. Whereas twenty years ago the removal of tuberculous glands in

TABLE

(*A*) Circular System of Glands	(1) Upper		(*a*) Submental.
			(*b*) Sublingual.
			(*c*) Submaxillary.
			(*d*) Facial or Supra-maxillary.
			(*e*) Parotid. Pre-auricular.
			(*f*) Mastoid or Post-auricular.
			(*g*) Occipital.
			(*h*) Retro-pharyngeal.
	(2) Lower		(*a*) Supra-clavicular.
			(*b*) Supra-sternal.
(*B*) Vertical System of Glands	(1) Superficial		(*a*) Anterior jugular.
			(*b*) External jugular.
	(2) Deep	Upper	(*a*) Anterior.
			(*b*) Posterior.
		Lower	(*a*) Anterior.
			(*b*) Posterior.

the neck figured largely on the operation lists of almost every hospital, such dissections are now becoming more rare every year, owing to the fact that more cases are being treated by conservative methods and also to the fact that the disease itself is less common. One instance of this may be cited by a reference to the operation records of the Belgrave Hospital for Children where, according to Wakeley, there were 240 operations performed for tuberculous glands in the neck between the years of 1909 and 1913, and only 18 between 1929 and 1933.

Tuberculous glands in the neck are most common during the first decade of life, 50 per cent of cases occurring between the ages of 1 and 10. According to John Fraser, this age period is one in which the child is liable to come into contact with tubercle bacilli through the medium of infected milk; at the same time, the lymphatic system is profuse, highly active in its absorptive function, and yet only partially educated in the properties of resistance. Handford of America gives the following table:

AGE PERIOD.	PERCENTAGE OF INCIDENCE.
1–10	40 per cent.
10–20	35 per cent.
20–30	20 per cent.
over 30	5 per cent.

Most observers are agreed that the incidence is slightly more common in females.

Amongst the predisposing factors may be included any conditions which lower the general health. These may be repeated attacks of

tonsillitis: the exanthematous diseases, particularly measles, whooping-cough and scarlet fever: oral sepsis, especially carious teeth; chronic pharyngitis; repeated attacks of chronic simple (non-specific) adenitis; chronic otorrhœa associated with middle ear disease; and a number of other conditions, such as eczema of the face, impetigo, pediculosis, sores, cracks, fissures, abrasions, etc., of the face, scalp or neck. In cases of primary tuberculous disease of the tongue, larynx, lung, etc., there may be a *secondary* tuberculous lymphadenitis involving the glands of the neck. As previously stated, the bovine infection—infection by milk—predominates in children, but with increasing age infection with the human strain becomes more common.

The chief routes through which the human organism becomes infected with tubercle bacilli are: (1) the pharynx, and especially the tonsils and adenoids; (2) the mucous membrane of the bronchial tree; (3) the mucous membrane of the last foot or two of the ileum; and rarely (4) the skin. The tubercle bacilli penetrate the mucous membrane, usually without leaving any obvious lesion, and become transferred to the nearest lymphatic glands. Here they may remain and become imprisoned, or they may enter the venous circulation and so be carried to the lungs. Deposited in the lung parenchyma they may light up an infective process, or they may be sifted through the pulmonary tissue and then become lodged in the tracheo-bronchial glands, causing disease there. Alternatively, some of them may pass into the pulmonary veins and thence to the left heart, to be disseminated far and wide throughout the body by the arterial circulation. In the majority of cases of tuberculous glands in the neck, however, the infection is a local one, the bacilli gaining entrance to the lymphatics through the tonsils or the adenoid tissues of the naso-pharynx, or from the gums. Where the infection is blood-borne the enlarged glands are irregularly distributed, and there are, as a rule, constitutional symptoms.

Diagnosis. This may be simple, difficult, or even impossible unless a gland has been excised and submitted to microscopical investigation. Diagnosis is based on the following:

(1) The history of the case.
(2) The examination of the patient: (*a*) local; (*b*) general.
(3) Special examination: (*a*) complete blood count; (*b*) Wassermann reaction; (*c*) X-ray examination of the neck, lungs and abdomen.
(4) Aspiration and microscopical examination of the fluid withdrawn from an abscess.
(5) Biopsy of the enlarged glands.
(6) Guinea-pig inoculation.
(7) Tuberculin test.

In taking a history, inquiry will have to be made as to any recent illnesses, especially sore throats, etc., and whether or not there is any tuberculous disease in the family. Other details may also need to be investigated, such as the conditions under which the patient lives, the milk supply, etc., when the lump was first noticed, where it started, and whether or not it has progressively increased in size. In most cases there is a history of some long-standing cervical glandular swelling which is gradually enlarging, or the formation of an abscess which has burst, leaving a discharging sinus in the neck. As septic infection predisposes the lymphatic glands to an attack by the tubercle bacillus, a careful search must be made for any focus of infection, and special attention must be paid to the area drained by the glands. The scalp should be examined for any evidence of sores or pediculi, the face for infected pimples, cuts, etc., and the teeth, tonsils and pharynx for any signs of infection. The tonsil is recognised to be the most important focus of infection. Barrington-Ward, for instance, found that the tonsillar gland was the one chiefly affected in 97 out of 161 cases, and that in 43 other cases the glands in the anterior triangle were diseased, the probability being that the tonsil was the seat of infection.

The tumour in the neck should be carefully examined, and the following points noted: its size, shape, position and consistency; the condition of the overlying skin; any evidence of sinuses; and whether or not there is any sign of matting. Search should also be made for enlarged glands in other parts of the body, such as the axilla, groin, etc., and the investigation completed by an examination of the chest and abdomen. It should be remembered that, with the exception of pyogenic infection, tuberculosis is the commonest cause of enlarged cervical glands, and the diagnosis should be in little doubt if the glands become progressively and painlessly enlarged in spite of appropriate treatment. Pain is always present in cases of peri-adenitis or caseation. In the average case, a firm, elastic, somewhat movable, elongated swelling will be detected in the neck (usually not tender on palpation), and smaller discrete nodes may be made out nearby. When caseation takes place the glands become boggy, and later a fluctuating, ill-defined mass, or a definite abscess, will be found. In neglected cases such an abscess may accumulate under the skin, burst, and discharge watery pus containing solid yellow flakes of necrotic tissue. There may also be evidence of toxic absorption, the patient being pale and languid, and suffering from evening rise of temperature with night sweats, lack of appetite, and loss of weight.

Tuberculous disease may be diagnosed if, after the removal of any obvious source of sepsis, the glands continue to enlarge, or do not disappear after a period of, say, three months; if they show any alteration in consistency—i.e. becoming softer; or if, should an abscess form, the aspirated material presents the features usually associated with tuberculous pus.

The main difficulties in diagnosis concern the really early stages of the disease, when only one or two discrete enlarged glands can be felt, and a later phase, when cold abscess formation is associated with thinning and reddening of the overlying skin. In the former case, if an *immediate diagnosis is imperative, a biopsy will be necessary*, whereas

Fig 2237.—Tuberculous abscess in the neck due to a breaking-down lymphatic gland. (*By courtesy of Sir John Fraser.*)

the latter condition can be clinically distinguished from an ordinary pyogenic cervical abscess by noting that: (1) although the skin is red and thinned it is not œdematous; (2) fluctuation can be obtained across the whole area of reddened skin, and not only in its central part; and (3) the fluid collection is always lax and never tense (fig. 2237).

In *differential diagnosis*, tuberculous glands in the neck may sometimes be mistaken for the following conditions: (1) Simple (pyogenic) adenitis; (2) Hodgkin's disease; (3) malignant disease, e.g. lymphosarcoma or secondary carcinoma; (4) glandular fever; (5) lymphatic leukæmia; (6) carotid body tumour; (7) branchial cyst; (8) sebaceous cyst; (9) aberrant adenoma of the thyroid or thyroglossal cyst; (10) fibroma, lipoma, etc.; (11) dermoid cyst; (12) ranula; (13) actinomycosis; (14) cellulitis; (15) syphilitic disease of the

glands or gumma of the sterno-mastoid muscle; and (16) tumour of the submaxillary or parotid salivary glands.

Pathology. The pathological appearances of tuberculous glands in the various stages of the disease have already been discussed on page 4121, but it is necessary here to describe from the clinical aspect the three distinctive pathological types of tuberculous cervical adenitis:

(1) The caseous type; (2) the lymphoid type; and (3) the fibrous type.

The *caseous* type is most frequently seen in children, and here the glands, which at first are discrete, become matted together and soften, eventually leading to the formation of a cold abscess. A cold cervical abscess, which is sometimes termed a "collar-stud" abscess, occurs when the pus bursts through the capsule of the gland, burrows through the deep fascia, and forms a collection in the subcutaneous tissues. The communicating channel through the deep fascia is usually very narrow, and when such an abscess bursts through the skin or is incised, a chronic sinus is produced. In the *lymphoid* type the nodes are discrete and elastic, there being usually no peri-adenitis. If, however, this occurs, it is a late phenomenon, as is also caseation. This type is particularly difficult to diagnose from Hodgkin's disease, and even on microscopical section such differentiation may in certain cases be impossible. In the *fibrous* type, which is seen chiefly in adults, the glands are small, hard, shotty, and firmly adherent to the deep structures. The disease pursues a very chronic course.

Clinical Features. There are two main clinical types of the disease:

Type I—the Diffuse Type. Here adenitis is a manifestation of widespread tuberculosis, and the primary infection is situated in the mesenteric or mediastinal glands, and occasionally in the parenchyma of the lung itself. The chief features common to this type may be enumerated as follows: (1) The general health of these patients is usually poor, and they are thin, pale and anæmic; (2) there is generally active and obvious disease present in the tracheo-bronchial lymphatic glands, in the mesenteric glands, or in the lungs; (3) the glands are not greatly enlarged; they are soft in consistency, and often partially calcified; (4) the involved cervical glands are multiple, and are situated in both sides of the neck, and particularly in the posterior triangles, being frequently associated with enlarged nodes in the groins and axillæ; (5) the tonsils are not usually enlarged or septic, and adenoids or any associated affections of the throat are seldom present; the enlargement of the glands is, as a rule, first noticed after the age of puberty; and (6) the prognosis must always be guarded.

Type II—the Localised Type, which is far more common than *Type I*, and is seen chiefly in adolescence. Here the infection is purely a local one, originating in the tonsils, adenoids, or, more rarely, in the teeth, etc. There are four chief clinical features of this type: (1) The general health is good, there being no evidence of tuberculous lesions elsewhere; (2) one particular gland, usually the jugulo-digastric or tonsillar, is, as a rule, chiefly involved, other surrounding glands being affected to a lesser degree; calcification is rare; (3) the tonsils and adenoids are often enlarged and septic, there being frequently a history of repeated attacks of tonsillitis or dental trouble; and (4) the prognosis after removal of septic foci followed by appropriate treatment of the glands is good.

The *course of the disease* may be divided into three distinct stages: (1) The stage of latency; (2) the stage of hyperplasia and the early formation of tubercles; and (3) the stage of caseation, sometimes accompanied by the formation of abscesses and fistulæ. In the early stage of latency, the general condition is good. The glands themselves are moderately enlarged, indolent and painless, there being no other symptoms of any consequence. At a later stage, when caseation occurs, there will be malaise accompanied by languor, and there may or may not be a slight evening rise of temperature. When frank suppuration ensues, there will be a stiffness of the head and marked pain and tenderness over the indurated mass of glands in the neck. Should an abscess form it may become secondarily infected, and the overlying skin may become red and œdematous. When, however, the abscess bursts through the skin, pain and tenderness are at once relieved. At a late stage in the disease in neglected cases, when there is multiple involvement of the glands and abscess formation, the general condition will be poor, with asthenia, anorexia and fever, together with the danger of dissemination of the disease—miliary tuberculosis or tuberculous meningitis.

The following are some *common clinical types* of tuberculous adenitis belonging to Type II, each of which calls for a special line of treatment which will be described later: (1) A simple enlarged firm gland or group of glands; (2) diffuse indurated swelling, i.e. inflamed glands matted together owing to peri-adenitis; (3) fluctuating glands; (4) a cold abscess—collar-stud abscess; (5) chronic discharging sinus in the neck due to an abscess which has burst; and (6) tuberculosis of the skin in the region of the orifice of a sinus in the neck, or as the result of involvement of the skin from the wall of a tuberculous abscess.

Prognosis. The prognosis depends upon several factors, such as: (1) The type, virulence, and site of the infection; (2) the resistance of the patient; and (3) a correct choice of treatment for each individual case.

In a general way it may be stated that in the majority of cases of tuberculous adenitis the patient's life is not directly threatened, but the infection is of a very chronic nature and treatment may be necessary for a considerable period, extending over months, and in many cases even years. It is, in fact, one of the least dangerous of the many forms of tuberculosis, as the disease is usually localised to the neck and rarely becomes disseminated. Disability is not marked, and in most instances the patient seeks treatment at an early stage on account of the unsightly lump in the neck and through fear that if an abscess forms it may burst through the skin. It is important to establish as far as possible whether the disease in the neck is blood-borne or lymphatic-borne. If the latter is the case, the prognosis is good, as the enlarged glands are evidence of a local infection and local resistance; whereas in a blood-borne infection there is always the danger of tuberculous septicæmia and spread of the disease to other organs.

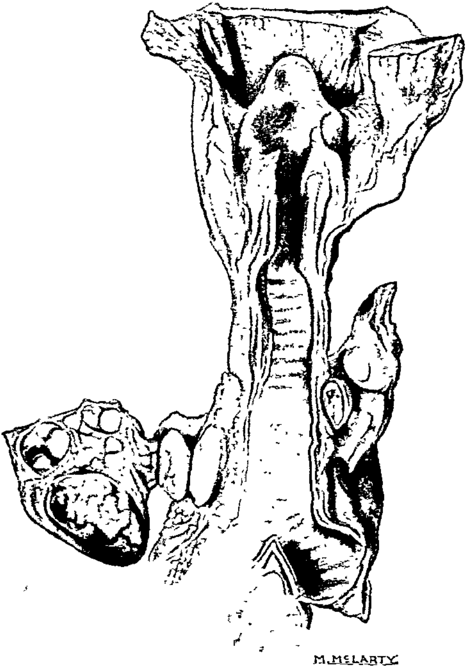
As already stated, the prognosis is definitely bad during the first two years of life, as the disease is then eager in its course, and death from tuberculous meningitis often ensues. The prognosis is good when the tonsillar gland or the glands in the upper deep cervical group are involved. It is, however, more serious when the supra-clavicular nodes are infected, when both triangles of the neck are simultaneously involved, or when the disease shows a haphazard distribution, e.g. a few scattered swollen glands in the neck, and obviously enlarged glands in the axillæ.

The *treatment* of tuberculous glands in the neck is discussed on page 4145.

(B) *Tuberculous Disease of the Mediastinal or Tracheo-Bronchial Glands*

Tuberculosis of the tracheo-bronchial glands is primarily a disease of childhood, and the treatment is wholly medical. In children the infection is usually by the bovine strain, whereas in adults it is chiefly of the human type. The point of entrance of the infection is nearly always in the intestinal tract or in the bronchial tree. The tubercle bacilli penetrate the mucous membrane of the small intestine or bronchioles, and are carried to the nearest lymphatic gland. Here they may become imprisoned, or they may escape and travel by way of the veins to the right heart, and thence to the lungs. In children the bacilli, which

are brought here by the blood stream, may form a small, relatively innocent focus in the lung (Ghon's focus) which heals spontaneously without clinical symptoms, or may pass directly through the lungs without being arrested until they are finally entrapped by the tracheo-bronchial



...NDS. (*Museum, London Hospital*)

glands where they light up a chronic infective process (fig. 2238). This gives rise to a vague combination of symptoms which may be grouped as follows: (1) Sallow complexion; (2) undue fatigue; (3) irritability and peevishness; (4) anorexia and malnutrition; (5) intermittent pyrexia; and (6) paroxysmal coughing.

It is *almost impossible to make a correct diagnosis* by ordinary physical methods and by radiological examinations before calcification has taken place in the diseased glands, but the condition may often be rightly suspected if, in the absence of physical signs in the chest and

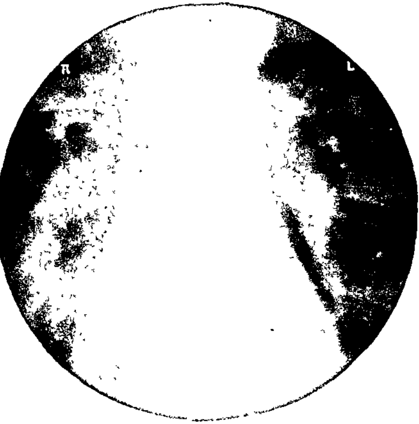


Fig. 2239.—Calcification of the tracheo-bronchial glands. (*Bull.*)

with negative X-ray findings, it is known that the patient has been exposed to the infection, if it is seen that he is rapidly losing ground, and if the tuberculin test is strongly positive. When skiagrams show calcification of the tracheo-bronchial glands it implies that the disease is well established or healed, having been present for a period of at least some months (fig. 2239).

If suppuration occurs in the mediastinal glands, an abscess may form and press upon the following structures:

(1) The *trachea*, causing shallow breathing and weak respiratory murmurs all over the lungs. (Dyspnœa may be alarming and may be accompanied by

explosive and paroxysmal attacks of coughing.) (2) The *bronchus*, causing absent or diminished respiratory sounds and restricted mobility of the affected side. (3) The *œsophagus*, causing dysphagia. (4) The *recurrent laryngeal nerve*, causing loss of voice or hoarseness, often accompanied by paroxysmal coughing. (5) The *superior vena cava*, causing obstruction of the large veins of the neck and face, arms and shoulders. (6) The *vagus nerve*, causing tachycardia and even vomiting. (7) The *sympathetic nerve trunk*, causing dilatation or contraction of the pupil on the affected side from pressure or irritation. (8) The *thoracic duct*, causing rupture and chylothorax.

The abscess may rupture into the following sites:

(1) The *trachea*, causing violent coughing, dyspnœa, or even death from suffocation. (2) The *pleura*, producing pleural effusion or empyema. (3) The *pericardium*, causing an embarrassment in the heart's action. (4) The *large blood-vessels of the mediastinum*, causing a widespread dissemination of the disease. (5) The *œsophagus*, causing dysphagia and the vomiting of tuberculous pus. (6) The *posterior mediastinum*, tracking round to the surface of the skin where it may form a localised abscess and eventually discharge through the skin, the axillæ and supra-sternal notch being common sites.

Treatment. This consists of: (1) Isolation of the patient and institutional treatment; and (2) general prophylactic measures, such as prolonged rest, and abundance of fresh air, sunshine, nourishing food with an ample vitamin content and the inclusion of malt and cod-liver oil, and, possibly, X-ray or tuberculin treatment.

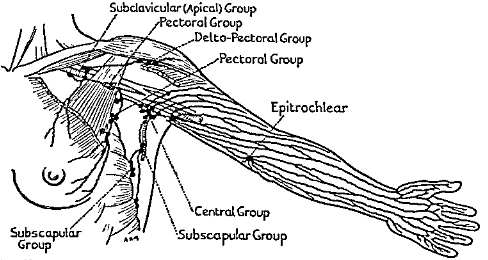


Fig. 2240.—A SCHEME OF THE LYMPHATIC GLANDS AND LYMPHATIC VESSELS OF THE UPPER EXTREMITY AND AXILLARY REGION.

(C) *Tuberculosis of the Axillary Lymph Glands* (fig. 2240)

The axillary lymphatic glands may become infected with tuberculous disease in three chief ways:

(1) From a local tuberculous lesion, e.g. tuberculosis of the breast,

anatomical tubercle of the hand, such as may occur following the performance of a post-mortem examination, etc. (2) By extension from tuberculous glands in the neck, and especially the lower deep cervical group of glands. It is nevertheless possible (though very rare) that organisms may gain entrance through the throat, and pass by a direct route through the lymphatic systems of the neck without involving them, and thence to the axilla, producing tuberculous

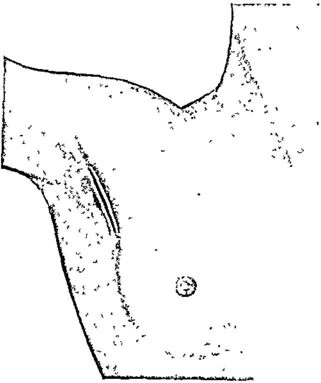


Fig 2241.—The incision employed for exposing a mass of tuberculous glands in the axilla or lying deep to the pectoralis major muscle.

lymphadenitis in the nodes in this region: (3) As a part of a generalised infection of the lymphatic system.

Treatment. Where tuberculosis of the axillary glands is a part of a generalised tuberculous process, the treatment should be conservative and follow general lines. Where, however, the disease is definitely localised to one or more of the axillary glands, the best treatment is prompt excision of all palpable infected nodes. No object will be gained by delay, as abscess and sinus formation so frequently occur, making subsequent dissection most difficult.

The best approach to these axillary glands is obtained by an incision which is made parallel to and a little behind the upper half of the anterior fold of the axilla (fig. 2241). The dissection is carried downwards through the deep fascia, the pectoralis major muscle is retracted upwards and inwards, and the glands are freed from the

great vessels and nerves of the axilla. When multiple sinuses are present it may be advisable to curette them and follow up the treatment by applications of X-rays. If this fails, then the mass should, where possible, be completely dissected out.

(D) *Tuberculosis of the Inguinal Glands* (fig. 2242)

This is a rare condition, even less common than tuberculosis of the axillary glands. It nearly always results from a local area of disease,

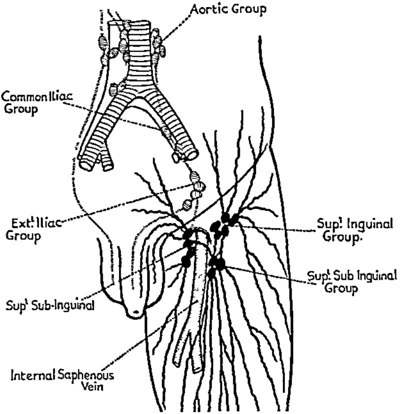


Fig 2242.—Scheme of the inguinal lymphatic glands.

such as tuberculous ulcer of the vulva or peri-anal region, or tuberculosis of one of the joints of the lower extremity. Occasionally, however, the infection may be blood-borne, when other glands also are usually involved.

On examination of such cases it is important to exclude venereal disease, and a meticulous search of the whole area must be made for any evidence of a local tuberculous lesion, an infected wound, or the scar of a recent wound. The glands themselves are enlarged, somewhat matted together, and tender on pressure, while there may be some associated stiffness of the limb. As it is important to make a prompt

diagnosis in these cases, it is often necessary to remove a gland and submit it to microscopical scrutiny so that suitable treatment may be instituted without delay. Tuberculous disease of the inguinal glands must be distinguished from the following conditions: (1) Acute pyogenic lymphadenitis; (2) inguinal and femoral herniæ; (3) bubo secondary to syphilis or soft sore; (4) lymphogranuloma inguinale;

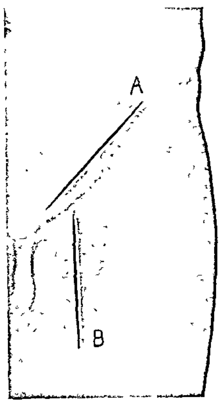


Fig. 2243.—A. Incision employed for dissection of external iliac group of glands. B. Incision for dissection of inguinal group of glands

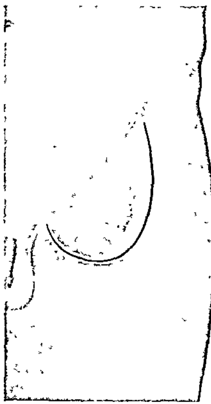


Fig. 2244.—Curved incision sometimes employed for exposure of inguinal glands.

(5) psoas abscess; (6) Hodgkin's disease; (7) primary or secondary malignant glands of the groin; and (8) encysted hydrocele of a hernial sac.

Treatment. Small lymphatic glands which are causing little or no inconvenience and which are not rapidly becoming larger may be treated by conservative measures. Those, however, which are large—and particularly those in which considerable matting has occurred and formed a definite tumour—are best treated by excision, when a portion of the saphenous vein may have to be removed together with the infected glands. The incisions commonly employed for dissecting out infected glands in the groin are depicted in figures 2243 and 2244.

When the *external iliac glands* which lie to the outer side of the

external iliac vessels are involved, they may be removed by making a transverse incision through the skin and abdominal muscles, $1\frac{1}{2}$ inches above the outer half of the inguinal ligament. After retracting the upper edge of the incision firmly upwards, the peritoneum is exposed and stripped off the glands, which are thus brought into view so that they can be dissected out.

(E) *Tuberculous Mesenteric Lymphadenitis*

The lymphatic glands of the abdomen are classified into two large groups, visceral and parietal, each of which is sub-divided into smaller groups according to the organs or regions they drain.

Thus:

Visceral	Parietal
gastric.	iliac.
pyloric.	lumbar.
splenic.	sacral.
hepatic.	aortic.
pancreatic.	anterior abdominal.
mesenteric.	
ileo-cæcal.	
colic.	
cœliac.	

In tuberculous mesenteric lymphadenitis the lymph glands of the mesentery and retroperitoneal space become enlarged, and often caseate: occasionally they suppurate or calcify, calcification being more frequent (fig. 2245). The condition is most often seen in early childhood, when it must be assumed that it originates from the consumption of milk obtained from tuberculous cattle. The incidence varies very considerably in different parts of the world, as John Thomson has emphasised. He writes:

> "Scotland enjoys the unenviable distinction of having more abdominal tuberculosis than any other civilised country—twice as much as England generally, and more than ten times as much as Europe and North America."

The disease may be a primary lesion, or may be secondary to tuberculosis of the intestine or lungs. In the *primary* cases, the glands become infected without there being any evidence of disease in the intestine. It must therefore be inferred that the bacilli have passed directly through the intact intestinal wall, or that a small lesion has formed which has healed so completely that no evidence of it remains. In the *secondary* cases, there are gross tuberculous lesions in the lungs or intestines which account for the lesions in the abdominal glands. The commonest sites of infected lymph nodes are the ileo-cæcal angle,

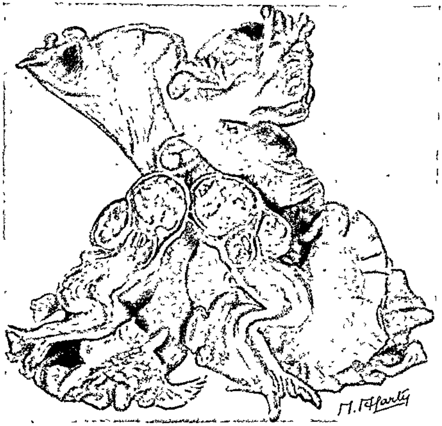


Fig 2245.—Tuberculous glands in the mesentery. (*Museum, London Hospital.*)

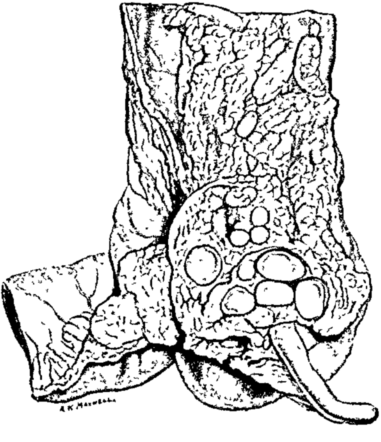


Fig. 2246.—Tuberculous glands of the ileo-cæcal region (posterior aspect). (*Museum, Royal Infirmary, Glasgow.*)

the retroperitoneal spaces medial to the cæcum and ascending colon, and the lower part of the mesentery of the small intestine. Occasionally a single chain of glands will be seen following the course of the ileo-colic artery to the root of the mesentery (see fig. 2246).

Diagnosis. On X-ray examination, visceral mesenteric glands, when calcified, have a conglomerate appearance like the aggregation of many small particles, the ileo-cæcal group being the one most commonly affected (fig. 2247). These calcified glands are found in the right iliac fossa; they can be palpated in thin patients, and are sometimes

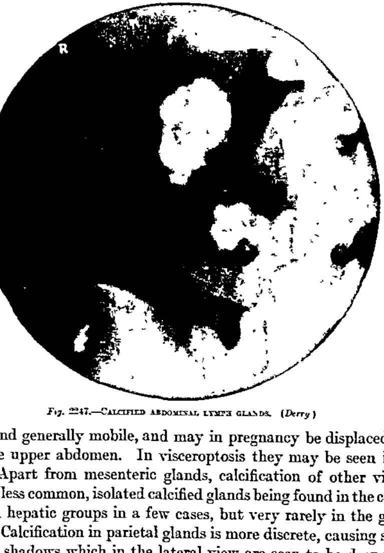


Fig. 2247.—Calcified abdominal lymph glands. (*Derry*)

tender, and generally mobile, and may in pregnancy be displaced high up in the upper abdomen. In visceroptosis they may be seen in the pelvis. Apart from mesenteric glands, calcification of other visceral groups is less common, isolated calcified glands being found in the cœliac, colic and hepatic groups in a few cases, but very rarely in the gastric groups. Calcification in parietal glands is more discrete, causing single, clear-cut shadows which in the lateral view are seen to be deep in the abdomen. Such shadows may be difficult to differentiate from renal calculi. Of the parietal glands the anterior abdominal group is very rarely calcified. The most difficult differential diagnosis is between a

calcified lumbar gland adjacent to a kidney pelvis and a renal calculus. These two conditions cannot be differentiated by antero-posterior and lateral films as in the other groups, and it is necessary both to examine the renal pelvis with a pyelogram and to take the clinical evidence into account. In the same way, gall-stones are distinguished by a cholecystogram. Calcified fibroids and lithopædion are larger than glands. Calcification around a foreign body assumes the shape of that body. The teeth in dermoids are usually recognisable as such. (Horny warts on the skin may throw shadows like those of calcified glands.)

Golden and Reeves found that in 23 of 29 unselected cases the glands were situated in the right lower quadrant of the abdomen. This localisation is attributed by them to the normal slowing up of the intestinal contents in the ileum, cæcum and ascending colon, which gives the organisms a better opportunity of passing through the walls here than elsewhere in the intestinal tract. All stages of the tuberculous process may be found in these mesenteric lymphatic glands—tubercle formation, caseation, and calcification. The older the patient, the more likely the glands are to contain calcium ; in young patients it is the exception, although occasionally a large, thick-walled, cystic tumour may be found which resembles a dermoid and contains yellow creamy material, together with depositions of chalk.

The disease is very protean in its clinical manifestations, but frequently three varieties may be recognised:

Clinical Types. In the *acute* type, which is so commonly seen in children, the symptoms mimic those of acute appendicitis, acute gastroenteritis, acute pyogenic abdominal lymphadenitis, or "gastric influenza." The patient feels languid and ill, and complains of intermittent bouts of abdominal pain specially referred to the umbilicus or right iliac fossa. The pain may be dull and dragging in nature, or sharp and colicky. Sometimes there are severe attacks accompanied by nausea and vomiting, and the pain may radiate to the back or down the thighs. After a day or two the pains tend to subside, only to recur later with added acuteness. The patient suffers from lack of energy of mind and body ; fever is usually continuous (99°–105° F.), although it may sometimes be intermittent ; and there may be constipation, although diarrhœa is the rule, the stools being thin, watery, dark, and extremely offensive. Diarrhœa is more likely to be present if there is any associated ulceration of the intestine. The face is pale, with flushed spots on each cheek, the lips are dry, the tongue coated, the breath foul, the extremities wasted, and the abdomen distended, tumid, and tender on palpation. This tenderness is most noticeable in the right

iliac fossa or in the hypogastrium, and on deep palpation one or two painful areas or palpable masses may be made out.

These cases are usually submitted to operation after a variable period of watchfulness and the performance of serological tests, a diagnosis of ? retrocæcal or pelvic appendicitis usually being made. At operation the appendix will be sought for, and although it will often be found to be normal in appearance it should, nevertheless, be removed in all cases. A little clear free peritoneal fluid will be present, and this must be quickly mopped up or evacuated by means of a suction tube. The glands in the mesentery and retroperitoneum are extremely plentiful, slightly enlarged, and rubbery in consistency; there is little or no peri-adenitis, but one or two nodes here and there may feel hard and gritty. *After removing a gland for biopsy, the abdomen should be closed without drainage.* The post-operative results are on the whole eminently satisfactory, although it is difficult to understand why this should be so. In some cases convalescence will be stormy, and recovery to health slow, while in a few cases death will follow from a rapid spread of the tuberculous process or from generalised tuberculosis.

In the *chronic* type of the disease, the involvement of the glands gravely interferes with nutrition, and the patient is wasted and anæmic, and tires easily on exertion. The symptoms are intensified by the frequent association of local tuberculous peritonitis. The abdomen is distended and tympanitic, but owing to the distension no enlarged glands can, as a rule, be felt. In some cases, however, nodules or a freely movable tumour mass can be made out to the right of the umbilicus. Diarrhœa is a constant feature, and the fat-laden stools are bulky, whitish, frothy from fermentation, and malodorous. There is a moderate pyrexia, but the general wasting and weakness are the most characteristic features. Anorexia, gastric upset, chronic abdominal pain, the discomforts associated with a gradually increasing distension of the abdomen, lassitude and drowsiness are the usual symptoms of which the sufferer from this disease complains.

The treatment of this condition is primarily medical, but during the course of the disease the following complications may occur and call for surgical measures: (1) Intestinal obstruction, which may be acute or chronic and which is due to adhesions which form between the breaking-down nodes and a neighbouring portion of the gut; (2) pressure effects upon neighbouring structures, e.g. at the root of the mesentery, compressing the third part of the duodenum and so producing duodenal ileus, or pressure or dragging upon the ureter causing ureteric colic or hæmaturia; and (3) perforation of a breaking-

down lymphatic gland, simulating ruptured appendix and causing a localised abscess or diffuse peritonitis.

In the *third* type, the disease is spent, and only the chalky tombstones of the dead bacilli remain as witnesses of the struggle that has once taken place. But although calcified abdominal glands are often clinically silent and innocuous, they may at times be the cause of recurrent crippling abdominal pains, severe colic, intermittent hæmaturia, or even intestinal obstruction.

Calcified abdominal glands are encountered in 65 per cent of subjects in the course of routine X-ray examinations. They are not commonly met with before the age of 12, and the sexes are affected with equal frequency. It is interesting to reflect that in the great majority of patients who have them, the glands affected are those of the ileo-cæcal group. This is a small group—four or five glands at the most—and yet it is the group picked out for tuberculous infection in about half the population.

Thomson-Walker found that in 11 out of 42 cases the symptoms were sufficiently severe to justify the removal of the calcified glands by operation. The result in all these cases was the disappearance of the pain, whether it had been in the nature of recurrent attacks of colic or of continuous dull aching. It is generally agreed that, since these glands represent the terminal stage of the disease and since, given careful surgical technique, there no longer exists a danger of dissemination of the tubercle bacilli, the question of whether to operate or not should depend upon the severity of the symptoms. Operation is only justifiable when the pain is recurrent and severe and is considered to be directly due to the presence of the glands. In those cases where hæmaturia is due to dragging on the ureter by a mass of glands, the abdomen should be opened and the culpable glands removed.

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CHAPTER III

The Treatment of Tuberculous Glands in the Neck

by

Rodney Maingot

Treatment may be either conservative or surgical. Conservative measures include all those which aim at a natural cure short of any attempt to excise a solitary gland or a group of glands. Although there are many adjuvants to conservative treatment, with regard to the value of which there are still differences of opinion, the main issues at stake in the treatment of this disease are the correct moment at which operation, if any, should be advised and the form it should take.

In a large number of cases a natural cure can be effected by adequate conservative measures before massive caseation has occurred in the glands. After this has taken place, there are only two methods of cure apart from operation: (1) The gradual replacement of the cheesy material in the gland by chalk; and (2) the complete caseation of all the glandular tissue, its subsequent softening and discharge through a sinus in the neck, and, finally, the shrinking and fibrosis of this sinus and the remaining gland capsule. Nature's method of cure, therefore, after extensive caseation has occurred, leaves unsightly masses or ugly puckered and depressed scars in the neck. Nature may be an excellent physician, but she is a crude surgeon. It would thus appear obvious that, in order to effect a rapid eradication of the disease with a minimum amount of scarring, surgery is clearly indicated after this stage has been reached.

GENERAL CONSIDERATIONS

It is impossible to lay down any definite rules to cover the treatment of all patients suffering from this disease, as so many factors influence the decision in each individual case. The following general considerations should, however, be borne in mind:

(1) The *age* of the patient may affect the choice of treatment. For instance, in infants up to 2 years of age conservative treatment should be persevered with, and if an abscess forms it should be treated on the simplest lines by incision and drainage. Older children, on the other

hand, are ideal subjects for radical operation. In adults exhibiting the characteristics of Type II of the disease (see page 4130), when softening of the gland takes place, operation should be undertaken without hesitation, for, although a noticeable scar may result, the disease, which would otherwise run a protracted course, is thus promptly eradicated. In old people the condition is comparatively rare and benign, and conservative measures should be persevered with unless the glands are *producing much pain or persistent discomfort.*

(2) The *occupation and the economic status* of the patient are often factors to be considered in the choice of treatment. For the average

Fig. 2248.—Tuberculous glands in the neck. (*By courtesy of Sir John Fraser.*)

patient who cannot afford the time or the expense of a prolonged course of conservative treatment, operation should be advised.

(3) The *extent and type of the diseased glands*, in other words, the pathological stage reached, will often be a determining factor in deciding upon the therapeutic measures to be adopted. For instance, a young adult who has no signs of active tuberculosis elsewhere in the body, and in whom the tonsils and adenoids and other local foci of sepsis have been removed, may present a number of different clinical manifestations calling for various lines of treatment. Ten examples of these are given below :

(*a*) A single mass of glands in the carotid triangle on one side of the neck, if seen early, requires conservative treatment ; but if, on the other hand, the disease is well developed and there are areas of softening, excision of the infected nodes should be undertaken (fig. 2248).

(*b*) *A mass of glands in each carotid triangle should be dissected out if there is no improvement after a brief course of medical treatment.*

(*c*) A mass in the submaxillary region on one or both sides indicates excision.

(*d*) A mass in the supra-clavicular region may, if small, be submitted to expectant treatment; but if it is large and gradually increasing in size, excision is to be preferred.

(*e*) Small scattered lymph nodes in one posterior triangle call for conservative measures, combined with X-ray or light treatment.

(*f*) Many scattered, small, discrete glands in one or both sides of the neck are an indication for general measures.

(*g*) A large mass may be found in one side of the neck with marked periadenitis. *Here local palliative measures are at first indicated. The head and neck* should be splinted, and fomentations applied.

(*h*) A "collar-stud" abscess should be opened, the aperture in the deep fascia

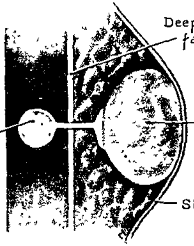

Fig. 2249.—Collar stud abscess

located and dilated, and the offending gland curetted out or completely excised (fig. 2249).

(*i*) *A large subcutaneous abscess, with the overlying skin thin and red, should* in the first instance be incised and its walls lightly curetted.

(*j*) *A sinus or sinuses in the neck without any appreciable underlying mass may* yield to heliotherapy and perhaps to X-ray treatment. If, however, there are persistent palpable underlying nodes, the sinus and the associated *glands should* be removed.

(4) The *presence or absence of tuberculosis elsewhere in the body* greatly influences the choice of treatment. *If the enlarged nodes in* the neck are a manifestation of a general disease, it is obvious that conservative measures should be persevered with indefinitely.

Conservative Treatment.

Under this heading the following points call for special consideration: (1) The elimination of all possible sources of local infection; (2) rest and attention to the general health, necessitating in certain cases

sanatorium treatment; (3) local adjuvants, which include: (*a*) applications to the affected glands; (*b*) aspiration of a tuberculous abscess, or aspiration followed by the injection of some antiseptic or sclerosing solution; (*c*) heliotherapy; (*d*) tuberculin treatment; (*e*) radio-therapy (radium or X-rays); and (*f*) drugs.

The object of conservative treatment is to increase the natural resistance of the body by general and local measures, so that the course of the disease is arrested. As John Fraser puts it:

> "The various measures adopted under this scheme so increase the local vascularity and resistance that barriers of fibrous tissue are deposited around the diseased focus, the effect being to isolate the disease, to cut off its nutritional blood supply, possibly to strangle it by mechanical constriction, and eventually to convert it into a knot of fibrous or calcified tissue."

The *eradication of local septic foci* is the first step in treatment, and the tonsils, when present, should be enucleated by dissection *in every case* without question, whether they appear to be diseased or not. If there is adenoid tissue this also should be removed.

The measures usually adopted to improve the *general health* comprise fresh air and sunshine, a well-balanced diet, adequate sleep, rest (general and local), the best hygienic conditions possible, and careful attention to the bowels. Rest in bed with immobilisation of the head and neck will often have a surprising effect in producing both a subsidence of the glands and an all-round general improvement in the patient's condition. Ambulatory cases should be fitted with a poroplastic collar which holds the head rigid and does not exert any harmful pressure upon the glands. The collar is well padded with wool, and is worn both by day and by night.

Amongst the local adjuvants, *fomentations* will be required where there is marked peri-adenitis, or when a secondary infection is superimposed upon a cold abscess for which drainage has been provided. *Counter-irritants*, such as painting the neck with iodine or the use of iodine ointments, have been recommended for early mild cases before caseation has occurred; but such measures are generally deemed to be meddlesome and injurious. *Simple aspiration* of a tuberculous abcess in the neck may be indicated as an emergency measure, particularly when arrangements for operation cannot be made expeditiously. It is, however, an unsatisfactory routine method of dealing with the condition, as more often than not the fluid proves difficult to withdraw owing to its high degree of viscosity and owing to the needle so frequently becoming clogged with thick tuberculous debris. Again, the cavity soon refills, thus necessitating frequent repetition of the pro-

cedure, which is not free from a danger of the introduction of secondary infection, even though care be taken to thrust the needle through healthy tissue and not through the most prominent part of the swelling where the skin is thin and devitalised. The injection of antiseptic and sclerosing solutions into the abscess-cavity provokes sinus formation rather than a process of healing.

All observers are agreed that *heliotherapy*, real or artificial, is an important feature in the treatment, and it requires no further emphasis, as its benefits are so well known and outstanding. *Tuberculin* has at times been extensively used in this country in the treatment of tuberculous lymphadenitis, but it is as yet almost impossible to assess its true value. It is generally thought, however, that even Beraneck's tuberculin is not likely to arrest the tuberculous process once extensive liquefaction has occurred. Nevertheless, the results when treatment is instituted in the stage of peri-adenitis without softening are considered by Thompson to be very promising.

Radium and *X-rays* are both useful local remedies, but the dosage must be very carefully measured and the treatment be administered only by a skilled radio-therapist. Tuberculous glands in the stage before breaking down has occurred respond very well to radio-therapy in a large proportion of cases. The treatment is given in small weekly doses over a period of two to three months. It should here be stressed that excessive dosage may lead to rapid breaking down, and thus the most propitious moment for surgery may be missed. Glands which have broken down and which are discharging can sometimes be made to heal in a most satisfactory manner by means of X-rays, but here much depends upon the extent of the suppurative process. *Large* masses of broken-down glands with multiple sinus formation do not offer much hope of relief by this method of treatment, although occasionally striking results are obtained. On the other hand, *small* gland masses with one or two discharging sinuses may respond with remarkable rapidity and heal completely within a few weeks. It is generally accepted that although X-ray treatment has a definite place in the management of cases of tuberculous glands in the neck, it is not, as a rule, to be recommended where there is abscess formation, where calcification or caseation is evident, or where the enlarged glands in the neck are complicated by secondary infection. The mode of action of X-rays in tuberculosis is not clear, as it has been incontrovertibly proved that no effect upon the tubercle bacilli is obtained with clinical dosage.

Treatment with *ultra-violet rays*, both by local and general

applications, has been recommended by some authorities for the following types of cases: (i) Superficial sinus or scrofuloderma; (ii) scattered enlarged nodes in one or both triangles of the neck; and (iii) in certain instances following radical excision, particularly where an extensive dissection has been effected. But, in my opinion, the majority of cases submitted to ultra-violet rays become worse while undergoing treatment, a fact which is also confirmed by Thompson (*St. Bartholomew's Hosp. Reports*, LXIX, 1936, 215). The *drugs* which are now most commonly prescribed are halibut- or cod-liver oil, and iodides, and these are usually given as a routine. Iodides are best administered in the form of syrup ferri iod. (B.P.) in full doses for periods ranging from two to three years, and are particularly useful in those cases where the glands have not reached the stage of gross caseation.

Operative Treatment.

According to the pathological state reached by the gland or group of glands affected, operative treatment will consist of: (1) Dissection of the involved gland or group of glands; (2) incision, evacuation, and curettage; or (3) secondary removal of a residual gland following (2). A detailed description of each of these methods will be given later.

Although excision of tuberculous glands in the neck was formerly a very common procedure, nowadays operation is only advised after careful deliberation and with discrimination. The nature of the operation will therefore depend upon the position and extent of the disease, whether or not an abscess or a sinus is present, and whether one group of glands or more is involved. Operation is indicated under the following conditions: (1) Where a group of large glands in the neck shows no signs of resolution after removal of all septic foci and after a course of conservative treatment; (2) when, in the local type of the disease, the glands are spreading from one group to another; (3) if there is any evidence of softening; (4) in all cases of abscess formation; (5) where, after incision and drainage of a cold abscess, a residual mass remains which shows no evidence of subsiding under palliative measures; (6) where one or more long-standing, mobile calcified masses cause unsightly tumours in the neck; and (7) in certain cases for cosmetic or economic reasons.

There are five main *contra-indications* to operation: (1) If the infection in the glands is believed to be blood-borne; for instance, where there is a haphazard distribution of the glands in the neck, associated with enlarged nodes in the axillæ or groins; (2) in children under two years of age; (3) in the senile and fibrous types of the disease; (4) in the stage of acute peri-adenitis; and (5) some cases where the

disease is seen at an early stage, when the gland, or group of glands, is small and mobile and there is no evidence of caseation. Here conservative measures are generally considered likely to prove successful.

It is in the last mentioned type of case that there is such sharp difference of opinion as to the relative merits of radical measures and conservative treatment. The opponents of surgical measures maintain that ugly keloid or puckered scars too frequently follow excision ; that nerve paralyses are by no means infrequent ; that it is often difficult to be quite sure that all the diseased glands have been excised ; and that tuberculous glands in the neck are more often than not a general rather than a local manifestation. They also affirm that the results of conservative treatment by modern methods are eminently satisfactory. Those who favour excision are of the opinion that the scar will be almost invisible if the operation is performed by a skilful and careful surgeon who understands the principles of plastic surgery ; that the scars themselves are less to be dreaded than the disease ; that nerve paralyses should not occur if the operation is carried out by one who is familiar with the anatomy of the neck ; that although there is a possibility of recurrence of the disease this is not sufficient to contra-indicate operation ; that in the majority of cases where a complete dissection of all the involved nodes is undertaken rather than a partial operation there should be no recurrence ; and that in most cases tuberculous glands in the neck are evidence of a local disease originating from the tonsils or adenoids rather than of a blood-borne infection.

Such authorities as Dowd, Miller, Tanner, Barrington-Ward, Grey Turner, Clute and Fraser consider that a radical removal of the disease in its early stage can effect a quick and permanent cure with good cosmetic results in over 90 per cent of cases, especially in children over the age of five years, and that the more advanced the disease the more difficult it is to cure by any means.

OPERATIONS FOR TUBERCULOUS GLANDS IN THE NECK

The technique of the various operations will be described under the following headings :

(1) Incision and drainage.
(2) Incision, evacuation, and curettage.
(3) Intra-capsular enucleation of the affected gland or glands.
(4) Radical excision :
 (*a*) General considerations.
 (*b*) Excision of individual groups of cervical lymph nodes.

Intra-Capsular Enucleation

Another operative procedure, deemed by some to be safer than radical excision of the infected nodes, is the "coring out" of the infected lymphoid tissue from its glandular capsule. By this method an incision is made over the glandular mass, and with a minimum amount of disturbance of the surrounding tissues *each* enlarged gland is palpated and a small incision made over it, after which its substance is enucleated, leaving the capsule itself and the surrounding lymphatic vessels intact. Thus the bulk of the infected tissue is removed without opening up any new fields to the spread of the disease.

This operation is superior to an incomplete dissection which cuts across actively diseased tissues and which is liable to cause a diffuse tuberculous cellulitis of the planes of the neck or even a generalised miliary infection.

Radical Excision

General Considerations.

(1) *Preparation of the Patient.* The patient should be admitted to hospital a day or two prior to operation so that he may receive the necessary pre-operative treatment and so that further investigations may be undertaken if required. The bowels should be opened by means of an aperient the day before the operation, and an enema should be given on the morning of the operation. A light diet rich in carbohydrates is prescribed, together with large quantities of fluids. The hair around the ears and back of the head should be shaved, and this area of skin together with the whole neck cleansed with ether soap, rinsed with sterile water, dried, and then painted with tinct. metaphen (Abbott), tannin-alcohol, or some other suitable disinfecting lotion. The use of iodine is not advised as it is very prone to blister the skin, particularly in children. A sterile dressing is applied and the whole neck is lightly bandaged. In males the head is tightly covered with thin gauze, the edges of which are made to adhere to the skin by means of collodion. In females a closely-fitting rubber cap covers the whole head so as to keep the hair away from the field of operation.

(2) *Choice of Anæsthetic.* Premedication should include large doses of atropin or omnopon with scopolamine, this being given about three-quarters of an hour before the actual commencement of the operation. Anæsthesia is induced with nitrous oxide, followed by oxygen and ether, after which a rubber tube is passed into the trachea through the nose, and anæsthesia maintained by the inhalation endotracheal technique (see Vol. I, page 16).

(3) *Position of the Patient.* The patient is placed in the dorsal position flat on the operating table, with a small sand-bag under the shoulders in order to extend the head, which is turned well over to the sound side so as to expose the affected area. After the primary dressings have been removed, the whole operative field is thoroughly painted with the antiseptic solution previously employed, after which towels are arranged so as to exclude all except the actual site of operation. For all operations upon the neck it is essential to have powerful illumination, in certain cases supplemented by a head-lamp, so that every minute structure can be readily identified.

(4) *Instruments.* The skin incision should be made with a fine Bard Parker knife. As soon as this is completed, the knife which has been used is discarded and a fresh one employed for the remainder of the dissection. This has the object of preventing any infection from

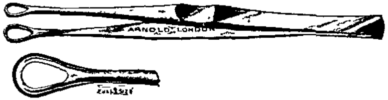

Fig. 2251.—Denis Browne dissecting forceps.

being carried by the knife from the skin surface into the deeper structures. The Mayo pattern of scissors and Dennis Brown dissecting forceps are useful instruments in any case where tuberculous glands require excision (fig. 2251).

(5) *Incisions.* The incisions will vary according to the site and size of the mass or masses to be removed, but all incisions are placed *transversely*, should lie as far as possible in the normal creases of the neck, and should correspond with the lines of stress. Vertical or T- or L-shaped incisions are now never employed for the removal of tuberculous glands in the neck because they leave unsightly scars, and are unnecessary, as there is no mass of glands, however large, that cannot be successfully removed through transverse incisions. Where glands occur simultaneously in the upper and lower parts on one side of the neck, two parallel transverse incisions should be made in preference to one long vertical one. For details of the various incisions employed when dealing with the removal of glands in the different parts of the neck see page 4161. Figure 2252 shows the various methods employed in suturing the wound at the completion of the dissection, A being that chiefly used by the writer.

(6) *Some points in technique.* After the skin incision has been made, tetra-cloths are affixed to the subcutaneous tissues of the edges of the

wound, but not to the skin itself. The incisions themselves should be large enough to afford a clear vision of all the structures. Hæmostasis must be complete and the dissection must be carried out with the utmost gentleness and daintiness, the point of the knife being kept close to the capsule of the gland. There must be no hurry or fluster, and each step must be complete before advancing to the next stage of the operation. Moynihan writes on this point as follows:

"In all the movements of the surgeon there should be neither haste nor waste. It matters less how quickly an operation is done than how accurately it is done.

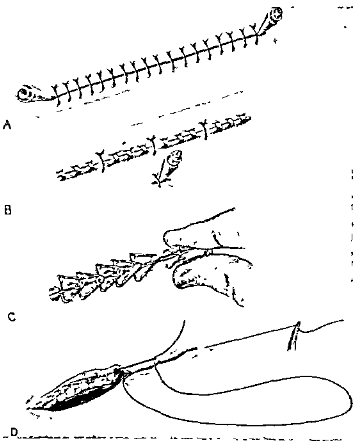

Fig 2252.—Methods of suturing the skin following excision of glands in the neck.
A. Interrupted sutures of fine silkworm gut.
B. Michel clips supported by tension sutures.
C. The insertion of Herff clips.
D Subcuticular stitch.

Speed should result from the method and the practised facility of the operator, and should not be his first and formal intention. It should be an accomplishment—not an aim. And every movement should tell, every action should achieve something. A manipulation, if it requires to be carried out, should not be half-done and *hesitatingly done*. . . . *Infinite gentleness*, scrupulous care, light handling, and purposeful, effective, quiet movements which are no more than a caress, are all necessary if an operation is to be the work of an artist, and *not merely of a hewer* of flesh. For every operation, even those procedures which are now quite commonplace, should be executed not in the spirit of an artisan who has a job to get through, but in the spirit of an artist who has something to interpret or create."

The infected glands must not be grasped with hæmostats or sharp-toothed *forceps for fear of spilling tuberculous material* in the wound. The nodes themselves must not be crudely avulsed with the finger or by blunt dissection with the handle of the knife, and disinfectants should on no account be poured into the wound either during or at the completion of the operation. Blood-vessels which have been clipped should be ligatured at once with fine catgut, and the wound should not be obscured by numerous hæmostats applied to bleeding points. Nothing must be severed *which cannot be identified, and no important structure* must be sacrificed. It is the surgeon's duty to see that such nerves as the spinal accessory and the muscular branches of the third and fourth cervical receive no injury. It is better to leave infected tissue behind than deliberately to injure any important nerve trunk.

The nodes must be removed *en bloc* together with the cellular tissues and fat in which they are embedded. If dissection of the glands is indicated, nothing short of a complete removal of all the involved nodes should satisfy the surgeon if a permanent cure is to be obtained. The tendency nowadays to remove only one or two large glands, leaving the remainder to look after themselves, cannot be too strongly condemned.

Great care should be taken in closing the wound, and the edges of the platysma should be most accurately approximated with closely applied interrupted sutures of fine catgut. Drainage is advisable in all cases, and this is best supplied by means of rubber cigarette drains of fine dental dam. The skin edges are usually united with interrupted sutures of fine silkworm-gut or horse-hair carried on small eyeless needles, the *individual stitches being placed close to one another (almost side* by side) and being tied with the greatest care to avoid tension and cutting or marking of the skin. Occasionally, Michel, Kifa or Herf clips are used, either singly or in combination with interrupted sutures. Most of the clips are removed in 24–48 hours and the stitches on the second, third or fourth day. If, however, a subcuticular stitch is used to approximate the skin edges, it should be left *in situ* for at least a week.

At the completion of the operation the head and neck are bandaged in such a way as to produce immobilisation, but not tightly enough to cause any obstruction of the veins of the neck which will lead to *congestion of the face.*

(7) *Post-Operative Treatment.* When the patient returns to bed, the usual anti-shock treatment is employed. After he has fully recovered from the anæsthetic he is placed in the sitting position, and

the head and neck are further immobilised. The dressings are changed in 24 hours, and the tubes are removed. If metal clips alone have been used to approximate the skin edges, it may be wise to remove the majority on the following day, leaving one or two in position for a further day or two in order to relieve any undue tension on the wound. Any collections of serum should be evacuated, and after each toilet of the wound the neck should be firmly bandaged. After the clips or sutures have been removed, lavish paintings of the wound with double strength calamine lotion are found to be not only agreeable and soothing to the patient but also helpful in reducing any œdema and in hastening healing and the formation of a sound fine scar. Short applications of well-screened radium plaques will reduce any tendency to keloid formation in the scar, and infra-red rays judiciously given have also a beneficial effect in expediting healing of the wound.

(8) *Difficulties, Dangers, and Complications.* The commonest reasons for disappointment following operations for the excision of tuberculous nodes in the neck are the following: an incision which is either too small or not well placed; poor illumination; lack of anatomical knowledge on the part of the operator; attempted excision when peri-adenitis is advanced and adhesions are numerous and firm; septic infection of the wound as a result of bad technique; and dissemination of the infection as a result of diseased tissue being cut across and all the involved nodes not being removed *en masse.*

Some of the more frequent *complications* may be conveniently discussed under the following headings:

(*a*) *Hæmorrhage.* The internal jugular vein may be torn or cut close to its exit from the jugular foramen, causing swamping of the wound with blood. This hæmorrhage can usually be arrested only with the greatest difficulty and with tedious waste of time. Hæmorrhage commonly occurs when the surgeon cuts blindly in the depths of the wound with scissors, or mistakes stretched blood-vessels for strands of connective tissue when undue traction is made upon the nodes during the process of dissection. When these taut blood-vessels are severed they immediately retract out of sight, flooding the wound and rendering the subsequent steps of the operation more difficult by obscuring the structures to be dissected.

(*b*) *Air-embolism.* This is prone to occur when the external jugular vein is cut close to the point where it pierces the deep fascia at the outer border of the sterno-mastoid muscle, just above the clavicle, or whenever the internal jugular vein or one of the other large veins in the root of the neck has been incised or torn across. The condition is

recognised by a sudden gush of dark blood into the wound, accompanied by hissing sounds produced by air being sucked into the vein. This accident may lead to sudden death unless prompt emergency measures are taken to check the entry of air into the circulation by pouring saline into the wound, by digital compression of the aperture in the vein, or by grasping the severed ends with hæmostats. In certain cases where the patient appears moribund after such an accident and shows no signs of recovery, it may be wise to make an epigastric incision, compress the heart, and squeeze it against the chest wall. This method of massaging the heart constitutes a rational attempt to force the bubbles of air onwards into the pulmonary vessels, but its chances of success are very remote, irremediable damage having already been done to the central nervous system.

(c) *Wounds of the thoracic duct.* (See page 4099.)

(d) *Formation of a hæmatoma* or cystic swelling due to exudation of divided lymph vessels. Should a cystic swelling form, the fluid should be evacuated by removing a stitch or two, or by probing the wound with sinus forceps. A small rubber tube or a strip of corrugated rubber should be inserted into the wound and stitched into position.

(e) *Injuries to important nerves.* The nerves most frequently injured in operations for tuberculous glands in the neck are the spinal accessory, the cervical branch of the facial nerve, the muscular branches of the third and fourth cervical, and the hypoglossal. If the spinal accessory nerve is severed before it pierces the sterno-mastoid, the muscle becomes partly paralysed and atrophic, but movements of the head are not greatly impaired, and there is no subsequent torticollis. Division of the nerve in the posterior triangle causes partial paralysis of the trapezius muscle, but no disability of any great consequence. Division of the muscular branches of the third and fourth cervical nerves together with division of the spinal accessory nerve causes paralysis of the trapezius muscle with atrophy. The shoulder on the affected side droops, and the inferior angle of the scapula becomes very prominent and is rotated towards the spine. The cervical branch of the facial nerve is too frequently divided during operation for removal of the upper deep cervical group of glands or the submaxillary nodes. This nerve sends twigs to the upper portion of the platysma, the depressor labii inferioris, and the risorius. Injury to this important nerve, which gives rise to temporary drooping at the angle of the mouth, must be avoided by dividing the platysma transversely on a level with the hyoid bone, fully 1 inch behind the angle of the jaw, and by dissecting the muscle with the upper flap of skin so that the nerve

is carried with this flap. When the hypoglossal nerve is severed there will be atrophy of the corresponding half of the tongue, which is protruded towards the injured side. It is surprising how well compensated this injury may be.

(9) *Results of Surgical Treatment.* The carefully followed-up cases of a large number of experienced surgeons have shown that a complete cure may be expected in over 90 per cent of the localised cases. For instance, in 1420 operations, John Fraser, one of the greatest authorities on this subject, had only 17 patients who returned for minor secondary operations. The best results are obtained in cases which come early for treatment before caseation is marked. The scar in such cases is hardly noticeable because extensive resection is unnecessary and complete excision is possible. If operation is undertaken before the appearance of sinuses and abscesses, recurrence is rare. If these complications are present and radical surgery is undertaken, it is obvious that the chances of complete cure are not so good; but, nevertheless, with modern technique and improved methods of carefully regulated doses of X-rays, the combination of surgery and radio-therapy for such cases offers good results. The operative mortality for excision of tuberculous glands in the neck is less than 1 in 2000. A few patients will die of post-operative pneumonia, which is preventable; from dissemination of the disease (miliary tuberculosis); from phthisis; or from tuberculous meningitis; but in the writer's experience such fatalities are happily unknown.

Excision of Individual Groups of Cervical Lymph Glands

(1) *Mastoid or Post-Auricular Glands.* These glands lie upon the upper part of the sterno-mastoid muscle over the mastoid process. They drain the adjoining area of the scalp, the back of the pinna, and the external auditory meatus, while their efferents drain into the upper deep cervical group. A transverse incision is made just behind the ear, over the swollen nodes, which are then dissected out. Nothing of importance will be divided except perhaps the posterior auricular vein or some twigs of the great auricular nerve.

(2) *The Pre-Auricular Gland and the Parotid Glands.* The pre-auricular gland lies immediately in front of the tragus, the situation being so constant that a swelling not exactly in front of the tragus cannot arise from this gland. The gland lies superficial to the parotideo-masseteric fascia, i.e. the fascia covering the parotid salivary gland. It drains the outer surface of the ear and the adjoining area of the scalp. The parotid glands are situated both in the superficial portion of the

parotid salivary gland and deep to it, i.e. between it and the side wall of the pharynx. The superficial glands drain the eyelids, the front of the scalp, the external auditory meatus, and the tympanic cavity. The deep glands receive lymph from the naso-pharynx and the back of the nose. The transverse facial vessels are on a superior plane under the zygomatic arch, while Stensen's duct is anteriorly placed and on a much deeper plane. The facial nerve is situated below and at a deeper level than the glands. The pre-auricular gland is removed through a small transverse incision immediately in front of the tragus (fig. 2253). *The greatest care must be taken in dissecting out the parotid lymph glands on account of the proximity of the branches of the facial nerve.*

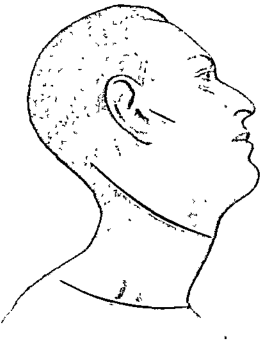

Fig. 2253 —Incisions employed for excision of tuberculous glands. The uppermost incision is used for dissecting out the pre-auricular gland. The lower two are employed for clearing out the upper and lower deep cervical groups of glands respectively.

A few twigs of the great auricular nerve will always be cut. In certain cases where there has been considerable suppuration of these glands with marked peri-adenitis, it is better to shell out the involved glands from their capsule rather than to dissect them out entire.

(3) *Occipital Glands.* These comprise two or three small glands which lie at the apex of the posterior triangle, midway between the mastoid process and the external occipital protuberance. They receive lymph from the posterior part of the scalp and are commonly enlarged and tender in pediculosis, eczema, or impetigo of the area which they drain. As the glands lie near the great occipital nerve they may, when they enlarge in tuberculous disease, press upon the nerve and cause neuralgia in the distribution of the nerve. These glands should be

removed by making a transverse incision over the anterior border of the trapezius, high up near the base of the skull. The great occipital nerve and the occipital artery are situated beneath the deep fascia on a deeper plane than the glands, and are not likely to be injured. The occipital vein, however, which is more superficial, will usually be divided.

(4) *Superficial Cervical Glands.* These glands lie in the superficial fascia around the external jugular vein on the outer surface of the sterno-mastoid muscle. They drain the parotid region and the lower part of the pinna. They are best removed through a transverse incision

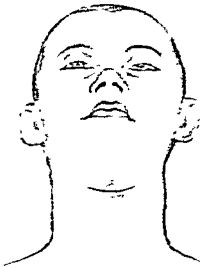

Fig. 2254.—Incisions used for removal of submental glands.

placed in one of the creases of the neck. If the superficial glands lower down are simultaneously involved, these also should be excised through a similar incision.

(5) *Submental Glands.* The glands here lie in the submental triangle on the deep fascia covering the mylo-hyoid muscle. The mylo-hyoid artery and nerve are situated on a deeper plane than the glands which drain the tip of the tongue, the central portion of the lip, and the floor of the mouth. The submental vein and the tributaries of the anterior jugular vein are necessarily divided when these glands are being excised. The incision usually employed for the dissection of these glands is a small transverse one placed midway between the point of the jaw and the hyoid bone (fig. 2254), or preferably just above the hyoid bone. Vertical incisions in this situation are to be deprecated, as they leave ugly scars.

(6) *Submaxillary Lymph Glands.* Most of the lymph glands in this region lie in the groove between the submaxillary salivary gland and the mandible, but some of them are embedded in the substance of the salivary gland itself. These glands drain the inner side of the eye, the cheek, the angle of the mouth, the side of the nose, the whole of the upper lip, the outer part of the lower lip, the gums, and a certain

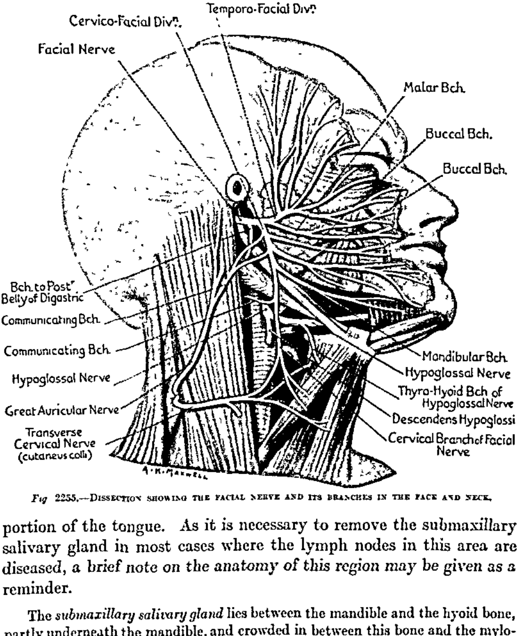

Fig 2255.—Dissection showing the facial nerve and its branches in the face and neck.

portion of the tongue. As it is necessary to remove the submaxillary salivary gland in most cases where the lymph nodes in this area are diseased, a brief note on the anatomy of this region may be given as a reminder.

The *submaxillary salivary gland* lies between the mandible and the hyoid bone, partly underneath the mandible, and crowded in between this bone and the mylo-hyoid muscle. Superiorly, it abuts on the mylo-hyoid line ; inferiorly, it is limited by the bellies of the digastric muscle ; posteriorly, it extends to the angle of the mandible, and is separated from the parotid salivary gland by fascia ; anteriorly, it reaches to a point corresponding to the mental foramen. It is the infero-lateral

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Fig. [illegible].—Incision used for dissection of submental glands.

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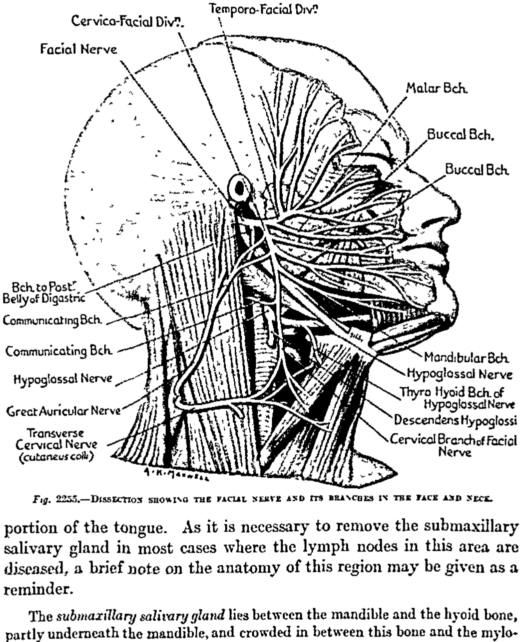

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surface that comes into view so readily during dissections of the glands in the neck. It is covered by skin, superficial fascia containing the platysma muscle and the cervical branch of the facial nerve, and the deep fascia. The *facial vein* crosses the gland close to its true capsule, but under cover of the deep fascia. The *facial artery* hooks forward above the stylo-hyoid and digastric muscles, producing a deep groove in the posterior portion of the submaxillary gland, to reach its lateral surface, and then proceeds downwards and forwards between the gland and the mandible to reach the lower border of the bone at the antero-inferior angle of the masseter muscle. At this point it pierces the deep fascia and runs upwards into the face. The *mandibular branch of the facial nerve* emerges from the lower end of the parotid salivary gland, pierces the deep fascia, and runs forwards below the mandible under cover of the platysma. It communicates with the transverse cervical and great auricular nerves, supplies the platysma muscle, and gives off twigs in an upward and inward direction to supply the muscles of the lower lip (fig. 2255). The *hypoglossal nerve* hooks round the external carotid artery, crosses the lingual artery, and proceeds forwards and inwards, deep to the tendinous portion of the posterior belly of the digastric muscle, where it will be seen to lie upon the hyo-glossus muscle below the deep part of the submaxillary salivary gland. This nerve lies deep to the fascia covering the hyo-glossus muscle, and should therefore be immune from injury during dissections in this part of the neck. It gives off branches to the muscles of the tongue. The *lingual nerve* lies under cover of the mandible on the hyo-glossus muscle at a much higher level than the hypoglossal nerve, and may be inadvertently severed when the submaxillary duct is being divided.

Operation. In all those cases where involved glands appear to be inseparably adherent to the submaxillary salivary gland, it is better to remove all the glands *en bloc*, including the submaxillary salivary gland itself: but where some of the superficial nodes only are diseased, the gland may be spared.

The incision commonly employed for the dissection of these glands is a curved one, starting in the mid-line between the symphysis menti and the body of the hyoid bone. From there it extends downwards to the level of the hyoid, passes outwards across the neck, and ascends along the anterior border of the sterno-mastoid muscle, to end 1 inch below the angle of the jaw. This incision is planned so as to avoid cutting across the mandibular branch of the facial nerve, the platysma being dissected upwards together with the upper flap. This incision does, however, leave a noticeable scar, and for results it cannot be compared with the alternative one—a transverse incision which is made just below the mandible in the shadow of the jaw (fig. 2256). This latter incision is deepened down to, but not through, the platysma muscle, and after ligature of all the bleeding points in the subcutaneous tissues, the upper and lower *skin flaps* are widely dissected off the underlying platysma muscle, which in this region is a comparatively thick

muscular band. The lower flap of skin is dissected downwards well below the ala of the hyoid bone, and is drawn firmly downwards with a small retractor. The platysma muscle is here carefully divided transversely, exposing the underlying deep cervical fascia. The upper edge

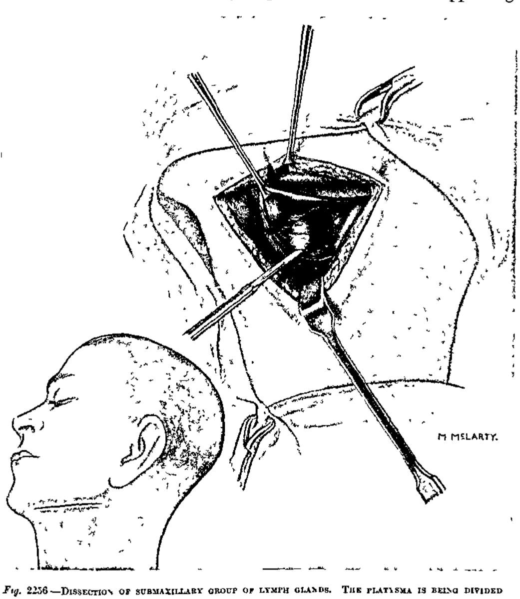

Fig. 2256.—Dissection of submaxillary group of lymph glands. The platysma is being divided low down to avoid the mandibular branch of the facial nerve.

(*Inset*) Incision placed in the shadow of the jaw. This incision extends only down to the platysma. After mobilising the skin flaps and retracting the lower edge firmly downwards, the platysma muscle is divided transversely low down in the neck to avoid injuring its nerve supply.

of the cut platysma muscle is seized with Allis forceps and retracted upwards to permit of this flap of muscle being dissected free from the underlying glandular mass, at the same time preserving its nerve supply and not in any way damaging the slender nerve twigs to the angle of the mouth.

The excision of the glands should now be undertaken after the deep cervical fascia has been freely incised. After the surgeon has tied the facial vessels, the submaxillary salivary gland with all the involved lymph nodes is dissected off the bellies of the digastric muscle and from the muscular floor of the triangle, i.e. from the mylo-hyoid, the hyo-glossus, and the superior constrictor. When the dissection reaches the border of the mandible, the facial vessels are tied at the lower edge of the bone at the antero-inferior angle of the masseter, where it is seen to pierce the deep fascia and bend upwards into the face. The greatest care must be taken in removing the deep part of the submaxillary gland and in tying off Wharton's duct, as the lingual nerve which crosses the duct may here be in danger of being injured. The hypoglossal nerve is at a lower level, lying on the hyo-glossus muscle above the hyoid bone, and is covered by fascia and the tendons of the digastric and stylo-hyoid muscles. It should not be injured if its position in relation to the deep part of the submaxillary gland and duct is remembered. In certain instances it may be advisable to remove the submental glands if they appear in the medial portion of the wound.

The wound is closed with the utmost care, the cut edges of the platysma muscle being approximated with closely applied interrupted sutures of the finest catgut, introduced with the greatest precision, and the skin edges neatly united with interrupted sutures of horse-hair or fine silkworm-gut.

Excision of the Upper Deep Cervical Group of Glands

The incision should always be generous so as to afford access to both the anterior and the posterior groups, and so as to permit of a radical removal of all the infected glands in this region. It should be so planned that it lies in one of the natural creases of the neck, and should commence at the *anterior border of the trapezius near the base* of the skull, and proceed obliquely downwards and forwards to finish in the middle line of the neck close to the upper border of the thyroid cartilage. It should likewise be below the tip of the mastoid process, and should not approach nearer than one finger's breadth to the angle of the jaw, lest the important cervical branch of the facial nerve be severed. The *incision is deepened for the whole length of the wound*, the platysma is divided, and the skin flaps with the adherent platysma are freely dissected in an upward and downward direction (fig. 2257). After all bleeding points have been ligatured, tetra-cloths are affixed to the skin edges, and the wound is then kept widely open by means of a Joll self-retaining thyroid retractor.

The sterno-mastoid (covered by deep fascia) will now be exposed, with the external jugular vein running vertically downwards over it, and the superficial nerves, i.e. the transverse cervical, the great auricular, and the small occipital, will be displayed near the middle of the posterior border of this muscle. A long segment of the external jugular vein (*together with any adjacent superficial glands*) *should* be excised, but an attempt should be made to spare the superficial nerves —in particular, the great auricular nerve, in view of its sensory supply to the side of the face. The anterior border of the sterno-mastoid is

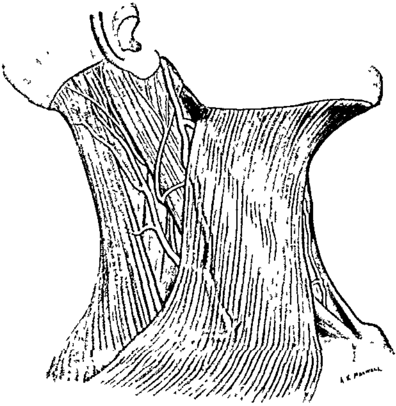

Fig 2257.—THE PLATYSMA MUSCLE.

now defined, a vertical incision is made through the deep fascia at the anterior border of this muscle, and the deep surface of the muscle is dissected off its sheath. If the muscle is infiltrated with tuberculous material, the infected portion must be excised. An effort should next be made to identify the internal jugular vein above and below the mass, after the sterno-mastoid has been firmly retracted backwards. The anterior group of glands is then dissected from the submaxillary salivary gland, and from the posterior belly of the digastric muscle above and the omo-hyoid below.

After the common facial vein has been ligatured, the glands are *separated* from the deep structures—the carotid sheath, and the middle

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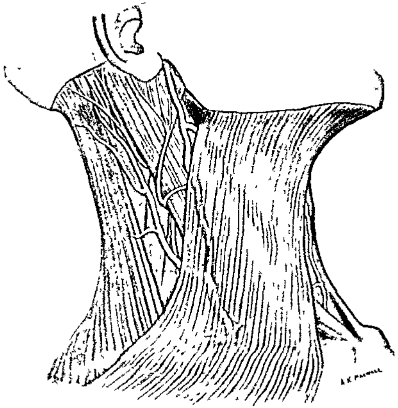

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After the common facial vein has been ligatured, the glands are separated from the deep structures—the carotid sheath, and the middle

and inferior pharyngeal constrictors. As the glands are stripped off the internal jugular vein in an upward direction, the spinal accessory nerve should be identified and cleared, after which dissection on a more superficial plane is carried out up to the lower portion of the parotid gland. The main trunk of the facial nerve issuing from the stylo-mastoid foramen lies above the posterior belly of the digastric muscle, but considerably further forwards near the mandible. The cervical division of the facial nerve, however, lies in the lowest portion of the parotid gland. covered by dense fascia, and is in danger of being cut in the dissection which is necessary when the masses have to be freed in this area. It should be remembered that, as the dissection proceeds in the upper part of the carotid triangle, the main mass of glands overlies the hypoglossal nerve, the occipital artery, and the internal and external carotid arteries, as well as the internal jugular vein.

In the majority of cases the glands will easily strip away where they are not adherent to the internal jugular vein, particularly after the sheath has been divided. If, however, they are firmly adherent to the vein, it will be necessary to resect a portion of the vessel in order to facilitate their removal. Owing to the many tributaries which join the vein in its upper part and render its isolation very difficult, it is better to divide the vein *inferiorly* and to dissect it upwards rather than the reverse. A lateral ligature to a wounded portion of the vein wall is not advised. as it is so prone to be forced off during post-operative vomiting. It is far better in such cases to divide the vein completely across and to tie both ends securely.

At an early stage of the dissection the spinal accessory nerve must be sought for. displayed, and freed from the glands. The nerve will be seen to enter the deep surface of the sterno-mastoid muscle from behind the posterior belly of the digastric muscle, approximately 1–1½ inches below the tip of the mastoid process. The sterno-mastoid branch of the occipital artery is a good guide to the nerve, as it runs to the muscle superficial to the nerve. If glands are felt in the posterior triangle, the deep fascia at the posterior border of the sterno-mastoid should be divided. and, after the muscle has been retracted forwards and inwards, the freed mass of glands in the anterior triangle is drawn into this area so that both groups of glands may be completely excised together. It is advisable to keep the surface marking of the spinal accessory nerve well in mind during the dissection of the posterior group of glands, as the enlarged nodes are apt to alter the course of the nerve, and considerable risk of injury is entailed if a prolonged and determined search for it is made amongst them. The nerve emerges about the middle of the

posterior border of the sterno-mastoid, and proceeds downwards and outwards, finally disappearing under the anterior edge of the trapezius muscle. The muscular branches of the third and fourth cervical nerves are often the main supply of the trapezius, and run below the spinal accessory nerve. They may be large, in fact individually larger than the spinal accessory nerve itself, for which they may be mistaken. When the spinal accessory nerve has been found, it is drawn aside, and the glands are then stripped from the back of the internal jugular vein.

Finally, the glands are dissected from the muscles of the posterior triangle, and after the small group that hides between the levator scapulæ and the splenius capitis has been freed, the whole glandular mass with its surrounding fibro-fatty envelope is removed. Hæmostasis is then assured, the platysma carefully sutured, drainage provided, and the skin edges accurately approximated.

Excision of the Lower Deep Cervical Group of Glands

These glands are removed through a curved incision which is made about two inches above the clavicle, commencing at the anterior border of the trapezius muscle and proceeding forwards to the middle line of the neck about 1 inch above the supra-sternal notch. The terminal part of the external jugular vein will be cut and tied at the posterior border of the sterno-mastoid muscle where it pierces the deep cervical fascia.

The descending, fan-like supra-clavicular nerves of the neck will likewise be divided. The incision is deepened and the deep fascia is divided transversely at the same level for the whole length of the wound. In order to expose the glands more clearly, the clavicular head of the sterno-mastoid muscle is divided about 1 inch above the clavicle and retracted inwards. Some surgeons, however, do not consider it advisable to divide the prevertebral fascia; in fact, without doing so, the glands can easily be removed, with no fear of damaging the phrenic nerve, the nerve of Bell, or the slender twigs which supply the rhomboid and the levator scapulæ muscles, all of which lie behind this strong fascial curtain.

The spinal accessory nerve should be identified and protected where it crosses the upper part of the incision and where it will be seen to lie on the levator scapulæ (fig. 2258). The posterior belly of the omo-hyoid is then sought for, and the fascia which binds it to the clavicle is divided, after which the glands are dissected from the floor of the posterior triangle in an upward direction. The fascia covering the

anterior border of the sterno-mastoid muscle is divided, and this muscle is retracted forwards and outwards to allow the freed glands to be drawn underneath it. The omo-hyoid muscle is drawn upwards and, after the transverse cervical and supra-scapular vessels have been

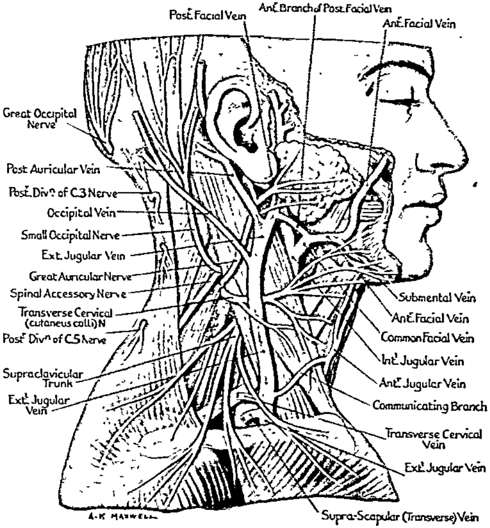

Fig. 2258.—The superficial nerves and veins of the neck.

tied, the glandular mass is forcibly drawn upwards and inwards in order to expose the main brachial nerve trunks.

The glands are now dissected off the internal jugular vein which lies deep to them. The vagus nerve lies behind the internal jugular vein in front of the vertebral vein, and will not be injured if the operator keeps the point of the knife close to the capsule of the glands, even when the involved glands extend behind this important vein.

While dissection is being carried out in this portion of the left

side of the neck, the white beaded thoracic duct will be seen, and should be protected from injury. *In those cases where all the cervical glands* on one side of the neck have to be removed through two transverse incisions, after the upper glands have been dissected free, they are drawn into the lower incision, and after the lower glands have been freed, the whole mass of glands is taken away *en bloc.*

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CHAPTER IV

The Dissemination of Malignant Disease

by

W. Sampson Handley

LYMPHATIC ANATOMY

A knowledge of lymphatic anatomy is an essential part of the equipment of the surgeon or the radiologist who has to deal with malignant disease. The reader is specially referred to Sappey's great work, *Les Vaisseaux Lymphatiques*, with its beautiful plates, to Leaf's translation of Poirier, Cuneo and Delamere's work, *The Lymphatics* (Constable, 1903), or to H. Rouvière's larger and more recent book, *Anatomie des Lymphatiques de l'Homme* (Paris, Masson, 1932).

It will be necessary to refer here to certain anatomical facts concerning the lymphatic system which are important in dissemination, though they are usually ignored in anatomical text-books.

Visceral Lymphatic Anatomy.

Each of the viscera has its own complex lymphatic system. It is a fact of capital importance in dissemination that underlying the pleura and peritoneum are rich subserous lymphatic plexuses co-extensive in area with the serous membranes and forming an easy highway for permeation. The subserous lymphatic plexuses are in communication through the muscular parietes with the great fascial lymphatic plexus to be later described. The meninges, though often said to be free from lymphatics, present a rich subdural plexus which must facilitate the spread of secondary cerebral deposits.

Parietal Lymphatic System.

In the parietes the lymphatic arrangements are relatively simple, and are of great surgical interest owing to the frequency of cancer of the skin and of its appendage—the mamma.

Fascial Lymphatic Plexus.

In the deeper layer of the subcutaneous fat, lying upon the deep fascia, is a rich lymphatic plexus—the fascial plexus, which forms a network, close-meshed in some parts such as the palm of the hand, more open in the less vascular regions (fig. 2259). This plexus is a single unity, a complete network of fine channels investing the entire

body, and is the main highway for the spread of parietal cancer. Beneath the breast the fascial plexus has received the special name of the pectoral lymphatic plexus. The middle line does not interrupt the continuity of the fascial plexus.

Efferents of the Fascial Plexus.

Arising from the fascial plexus and running in the subcutaneous fat are lymphatic trunks which convey its lymph to the lymphatic glands, cervical, axillary, or inguinal. These trunks are special to particular regions, between which the only lymphatic connection is provided by

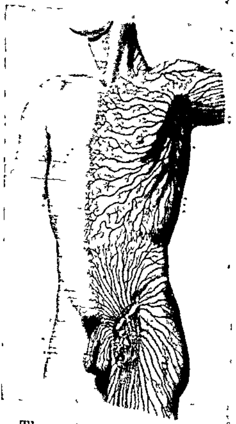


Fig 2259.—FROM A PLATE IN SAPPEY'S "VAISSEAUX LYMPHATIQUES," SHOWING THE LYMPHATIC PLEXUS (FASCIAL LYMPHATIC PLEXUS), WHICH LIES IN THE DEEPEST LAYER OF THE SUBCUTANEOUS FAT, AND FORMS *THE MAIN HIGHWAY FOR PERMEATION* IN CANCER AFFECTING THE PARIETAL TISSUES *AND FOR LYMPHATIC INFECTIONS* NUMEROUS TRUNKS ARE SEEN ARISING FROM THE PLEXUS AND PASSING TO THE AXILLARY OR THE INGUINAL GLANDS ALONG THESE TRUNKS EMBOLIC INVASION OF THE AXILLARY GLANDS OCCURS, THE TRUNKS THEMSELVES ESCAPING PERMEATION UNTIL A LATE STAGE. THE FINE MESHWORK OF VESSELS *CONSTITUTING THE FASCIAL PLEXUS* IS ONLY PARTIALLY INDICATED IN THIS FIGURE, SO THAT THE TRUNK LYMPHATICS ARE *MADE TO APPEAR* UNDULY PROMINENT

(*By kind permission of Messrs Kegan Paul, from Handley's "Genesis of Cancer"*)

the continuity of the fascial plexus. The parietes are thus divided into six lymphatic areas, three on each side. The two horizontal planes which separate these areas run round the body at the level of the clavicle and the umbilicus respectively.

Embolic invasion of lymphatic glands is restricted to the glands of the particular area in which the cancer originates, unless, by permeation through the fascial plexus, cancer-cells have transgressed the boundary zone and reached another lymphatic area. Lymphatic embolism across the boundaries of a lymphatic area is not possible. A knowledge of these simple facts makes it possible to say what glands must be removed or radiated for a superficial growth in any given position. Thus for

…eration-pressure of Cancer-cells.

… issemination of cancer is an effect of the ceaseless tendency to …liferate, which is a fundamental property of the cancer-cell. The …liferating masses of cells are forced quasi-mechanically along the

… A PERMEATED LYMPHATIC IN LONGI… …SECTION WITH NORMAL BLOOD-VESSELS ABOVE AND BELOW IT.

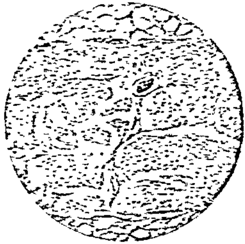
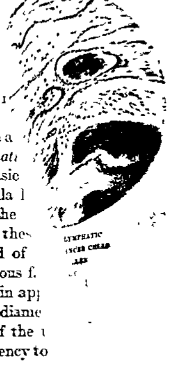
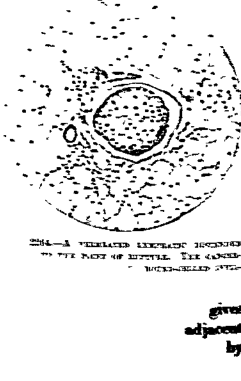


Fig. …—A PERMEATED LYMPHATIC IN TRANSVERSE SECTION. A SMALL BRANCH LYMPHATIC NOT YET … IS SEEN RUNNING INTO IT. … OF THE LYMPHATIC HAS NOT YET … NOTE THE ABSENCE OF ROUND-CELLED INFILTRATION.



… LYMPHATIC … CELLS …



…—A PERMEATED LYMPHATIC … THE POINT OF … THE CANCER … ROUND-CELLED …

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and cutaneous secondary nodules frequently occur, the intervening skin may show no sign of cancer. Such nodules are to be regarded as isolated "efflorescences" from the infected fascial lymphatic plexus beneath. The area of infected fascia is always larger than the area of skin showing nodules, a fact of great surgical importance.

Muscular Lymphatics.

Tributaries from the underlying muscles run into the fascial plexus on its deep aspect. The muscular lymphatics in turn communicate with the subserous plexuses. These fine anastomotic connections enable cancer-cells from superficial cancers to reach the cœlomic cavities. Sometimes, on the other hand, the cells of visceral cancers may thus reach the fascial plexus and may produce subcutaneous nodules.

Concomitance of Lymphatic Vessels and Blood-vessels.

Just as gas, water and electric mains often run in the same conduits, so in the body an artery, one or two veins and two lymphatic vessels are normally found in company, and this fact has important consequences, for the rupture of a cancerous lymphatic may initiate infiltration round the concomitant vessels with ultimate invasion of the venous or arterial lumen. In melanotic sarcoma I have traced all stages of this process. It probably also occurs in late stages of carcinoma.

Initial Obstacles to Dissemination.

It is to be noted that at first the cancer-cells have no access to the vessels either of the lymphatic or of the hæmic system. The hæmic system is, of course, a completely closed one. The lymphatic vessels also form a closed system which does not communicate with the tissue interspaces. The lymphatic capillaries begin as closed sacs of endothelium which unite to form lymphatic vessels, and these to form larger lymphatic vessels, which, after passing through a series of filter-beds—the lymphatic glands—empty into the venous system by the thoracic duct, the right lymphatic duct and, according to Leaf, by a communicating vessel in the groin.

It is further to be noted that according to my observations (*Genesis of Cancer*, Kegan Paul, 1931), pre-cancerous areas are areas in which the lymphatics have been destroyed by previous attacks of obliterative lymphangitis. Permeation can only begin when the infiltrating cancer-cells reach patent lymphatic vessels. Hence the primary growth usually attains a considerable size before enlargement of the glands indicates that lymphatic spread has begun. If the area of pre-cancerous obliteration of the lymphatics is a very large one, as, for instance, in lupus-cancer, dissemination is usually prevented, however locally malignant the disease may be.

instance, for a growth at the right margin of the anus, or on the right lower extremity, or on the right side of the back below the level of the umbilicus, only the right inguinal glands will need removal. In an early cancer of the breast only the homolateral glands will be affected, but as soon as permeation crosses the middle line, embolic infection of the glands of the contralateral axilla occurs.

If a growth starts at the junction of two lymphatic areas two sets of glands will need removal. For example, in a squamous-celled carcinoma in the middle line below the umbilicus, both sets of inguinal glands must be removed. A similar growth at the level of the umbilicus

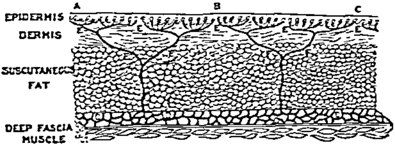

Fig. 2260.—To show the lymphatic arrangements of the skin. A schematic vertical section of the skin and subcutaneous fat, with a small horizontal shelf of deep fascia projecting forward from it. Below this is muscle in vertical section. AB and BC are two of the primary lymphatic areas of the skin. These areas measure one-third to half an inch in diameter, and the only lymph-vascular communication between them appears to be by way of the subjacent fascial lymphatic plexus DDDD, which is seen on the flap. The lymphatic end-sacs of the skin papillæ unite by groups of five or six to form small lymphatic vessels, which again unite in the superficial third of the dermis (plane of primary confluence EEE) to form other lymphatic vessels which pierce the dermis vertically and unite just beneath it (plane of secondary confluence FFF) into a smaller number of vessels which run down through the subcutaneous fat to discharge into the fascial lymphatic plexus DDD.

(Reproduced from the Author's "Genesis of Cancer," Kegan Paul, 1931)

and to the right of it would infect the axillary and inguinal glands of the right side. A growth actually at the umbilicus would simultaneously invade the axillary and the inguinal glands of both sides.

Lymphatic Anatomy of the Skin.

The basic fact in the minute lymphatic anatomy of the skin is that each papilla has as its central structure a minute capillary lymphatic end-sac, the same arrangement being seen in the intestinal villus. Groups of these end-sacs unite to form lymphatic vessels in the superficial third of the dermis and then continue vertically through the subcutaneous fat to join the fascial plexus (fig. 2260).

The skin appears to be divided into small lymphatic areas of $\frac{1}{3}$—$\frac{1}{2}$ an inch in diameter, between which there is little communication except by way of the underlying fascial plexus. It results that cancer has little tendency to spread in the plane of the skin. Though subcutaneous

and cutaneous secondary nodules frequently occur, the intervening skin may show no sign of cancer. Such nodules are to be regarded as isolated "efflorescences" from the infected fascial lymphatic plexus beneath. The area of infected fascia is always larger than the area of skin showing nodules, a fact of great surgical importance.

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Proliferation-pressure of Cancer-cells.

The dissemination of cancer is an effect of the ceaseless tendency to proliferate, which is a fundamental property of the cancer-cell. The proliferating masses of cells are forced quasi-mechanically along the

Fig. 2261.—× 150. A permeated lymphatic in longitudinal section with normal blood-vessels above and below it.

Fig. 2262.—A permeated lymphatic in transverse section. A small branch lymphatic not yet invaded is seen running into it. Distension of the lymphatic has not yet begun. Note the absence of round-celled infiltration.

Fig. 2263.—A permeated lymphatic beginning to be distended by the cancer-cells within it. The cancer-cells are swollen and show signs of incipient degeneration.

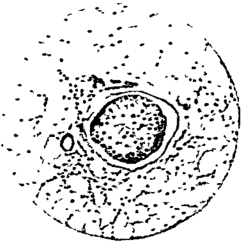


Fig. 2264.—A permeated lymphatic distended almost to the point of rupture. The cancer-cells are degenerate, and round-celled infiltration of the peri lymphatic tissues is beginning.

lines of least resistance. Rupture of the basement membrane gives the cancer-cells access to the intercellular spaces of the adjacent connective tissue, and their local spread through these spaces by infiltration forms the primary growth.

Invasion of the Vascular Systems.

The high pressure developed by infiltration at the site of the primary growth, and the erosive or digestive action of the cancer-cells upon the contiguous normal tissue, ultimately give the cancer-cells access to the lymphatic capillary system and also, though usually at a much later date, to the blood-vessels.

Permeation.

When cancer-cells enter a lymphatic capillary they find an open lumen along which they can easily grow as a continuous line or tendril of cells. I described this process in 1904 and named it *permeation* (figs. 2261 to 2269). At a certain stage in the formation of the primary

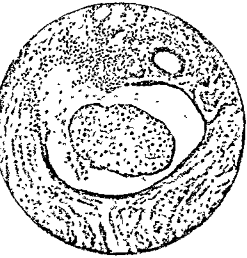


Fig. 2265.—RUPTURE OF A DISTENDED PERMEATED LYMPHATIC BY THE INCLUDED CYLINDER OF CANCER CELLS. INTENSE ROUND-CELLED INFILTRATION AND TRAUMATIC HÆMORRHAGE HAVE RESULTED FROM THE RUPTURE.

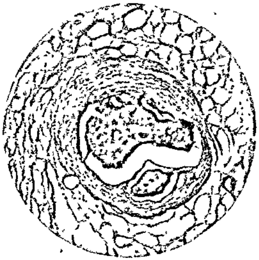


Fig. 2266.—SHOWS THE PROCESS OF PERI-LYMPHATIC FIBROSIS WHICH FOLLOWS RUPTURE OF A PERMEATED LYMPHATIC. THE CANCER-CELLS, NOW COMPLETELY DEGENERATE, ARE ENCLOSED IN A CAPSULE OF NEWLY FORMED FIBROUS TISSUE.

growth, the small lymphatics of the surrounding tissues beyond its infiltrating edge are permeated and the dissemination of the growth has begun.

Fate of Permeated Lymphatics.

It is quite difficult to find evidence of permeation in the tissues round the primary growth, unless the search is a systematic one. A permeated lymphatic is not a permanent structure. The proliferation of the contained cancer-cells distends and finally splits up the lymphatic vessel (figs. 2264 and 2265). Before rupture occurs, the internal pressure has so damaged and devitalised the cancer-cells that the vigorous inflammatory reaction which follows on the rupture, and the fibrosis which ensues, are able to destroy the cancer-cells. I have traced every stage of this process, which may be called *peri-lymphatic fibrosis* (figs.

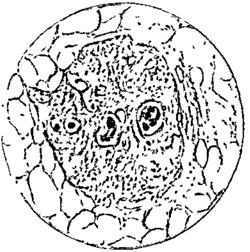


Fig. 2267.—THE PENULTIMATE STAGE OF PERI-LYMPHATIC FIBROSIS. THE ORIGINAL LYMPHATIC IS REPRESENTED BY A SOLID THREAD OF FIBROUS TISSUE CONTAINING REMAINS OF CANCER-CELLS. IN THE FINAL STAGE ALL TRACE OF CANCER-CELLS DISAPPEARS.

Fig. 2268.—×75. PERMEATED LYMPHATICS OF VARYING CALIBRES FROM A CASE OF BREAST CANCER. (*The Bland Sutton Pathological Institute, Middlesex Hospital.*)

Fig. 2269.—×430. THE PERMEATED LYMPHATIC SEEN AT A IN THE PRECEDING FIGURE MORE HIGHLY MAGNIFIED. NOTE THE ENDOTHELIAL LINING AND THE ABSENCE OF A MUSCULAR COAT. CENTRAL DEGENERATION OF THE CYLINDER OF CANCER CELLS IS BEGINNING. (*Photo, the Bland Sutton Institute.*)

2266 and 2267). It is a locally curative process, but, for reasons which a little consideration will make obvious, it is quite incompetent to arrest the spread of the cancer. It always occurs just too late, since the distension of the lymphatic which is preliminary to rupture and fibrosis forces the cancer-cells still further afield, into hitherto intact regions of the lymphatic network.

The Microscopic Growing Edge.

At a certain stage in the progress of the growth, and beyond its infiltrative growing edge, there is a devastated area, apparently normal to the naked eye, in which the permeated lymphatics have undergone fibrosis and have been replaced by solid threads of fibrous tissue. In this area there may be found here and there isolated microscopic secondary nodules of cancer, due to the sporadic and local failure of the protective process of peri-lymphatic fibrosis. Though apparently isolated, these nodules have arisen in continuity with the primary growth as terminal outcrops of the insidious process of permeation.

Beyond this devastated area a careful search may detect the real microscopic edge of the growth—a zone of permeated lymphatics a few millimetres wide. Here, distension, rupture and fibrosis are absent and there is no round-celled infiltration.

The gradual spread of permeation through the tissues is comparable to the spread of a ringworm from its point of origin. On any old tombstone with its lichens, or on the fireback with its spreading circles of incandescent soot, a similar process may be seen. In cancer it is invisible and can only be traced laboriously by the microscope, but sometimes it is clinically manifested in the centrifugal spread of a crop of subcutaneous nodules (see fig. 2270).

Epigastric Invasion of the Abdomen in Breast Cancer.

In breast cancer, permeation of the fascial plexus in the region of the ensiform cartilage frequently leads to permeation of the subperitoneal lymph plexus of the underlying parietal peritoneum. Transcœlomic implantation next produces nodules upon the adjoining upper surface of the liver, while at the same time cancer-cells fall into the pelvis and produce ovarian secondary deposits. Other cancer-cells may be encysted by the omentum with the production of nodular omental deposits, or may adhere to and grow upon any part of the peritoneal surface.

Invasion of the Fascial Lymphatic Plexus in Stomach Cancer.

In gastric carcinoma, permeation of the subserous lymphatic plexus over the growth may take place at an early stage, and cancer-cells soon escape into the peritoneal cavity. Transcœlomic implantation then

occurs, followed by permeation of the subserous lymphatic plexus near the site of the implantation. In the region of the umbilicus the subserous lymphatic plexus is only separated from the fascial lymphatic plexus by the linea alba, which is pierced by communicating lymphatics.

Fig. 2270.—Carcinoma of the breast in a man of thirty-eight with gynæcomastia. To illustrate the centrifugal spread of fascial permeation from its point of origin in the breast, with upstream local extensions to the skin forming cutaneous nodules.

(*Middlesex Hospital, 1930.*)

Permeation extends to the fascial plexus, and a crop of subcutaneous nodules, at first close to the umbilicus (fig. 2271), but extending centrifugally from it, may signalise the spread of permeation in the fascial plexus.

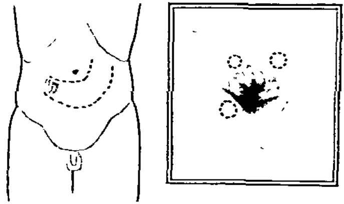


Fig. 2271.—The first stage of permeation of the fascial plexus in stomach cancer. A pyloric tumour in a man of middle age. Inset, the umbilicus, natural size, with three subcutaneous nodules, represented by dotted lines, which enabled the diagnosis of gastric carcinoma to be made with certainty.

These nodules may eventually spread up to the vertex of the skull, downwards to the middle of the thigh, and almost down to the elbow. The opposite convexities of the circle of permeation may meet in the middle of the back (fig. 2272).

A similar extreme extension of permeation in the fascial plexus is

sometimes seen in breast cancer, but here too the distal portions of the limbs escape so that blood dissemination is excluded. These extreme cases show that permeation is theoretically able to penetrate the entire body, since the finest anastomotic lymphatics offer no barrier to its advance. Fortunately, it is, as a rule, a slow process, though more rapid than infiltration.

Mode of Spread of Permeation.

Permeation begins at the edge of the primary growth and spreads away from it in a centrifugal manner, but owing to the anatomical

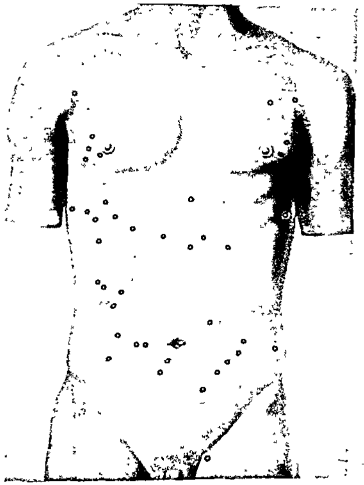


FIG 2272.—ADVANCED PERMEATION OF THE FASCIAL PLEXUS IN STOMACH CANCER. MANY OF THE ORIGINAL NODULES AROUND THE UMBILICUS HAVE DISAPPEARED.

arrangements of the lymphatic system the permeated area of tissue is not usually spherical. The process spreads most easily in the plane of the main lymphatic plexus of the part. Thus in cutaneous and mammary cancers the plane of maximal spread is the plane of the deep fascia, and this is the layer which requires the most extensive removal. But after a time cancer-cells are forced by the increasing pressure in the main plexus to grow into the little tributaries which reach it from the skin above and from the muscles beneath, and a smaller circular area of

skin and muscle is invaded. These facts are the key to operative treatment for all parietal cancers. They show that the portion removed must be accurately centred on the primary growth and that it must be circular in shape, since permeation spreads in a centrifugal manner. They indicate the necessity of removing a limited circular area of possibly infected skin around the primary growth. When this area has been marked out, thin skin flaps must be raised until a large circular area of deep fascia has been exposed for removal. This is circumscribed by a circular incision down to the muscles, and its thin edges are now raised up from the muscles, working from the periphery towards the centre of the operation field. Finally, an area of muscle subjacent to the primary growth is also removed. These are the general principles which govern equally an operation for breast cancer and one for any disseminating growth of the skin such as a melanotic sarcoma. The operation must also take into account the process of lymphatic embolism and remove the lymph glands in one piece with the primary growth, the permeated area of tissue around it, and the trunk lymphatics which run from the growth to the glands (" monobloc " operation).

Permeation around Secondary Deposits.

Not only does permeation occur round the primary growth, but also around every secondary deposit. Thus, for instance, when a lymphatic gland is invaded by lymphatic embolism its idle tributary and efferent lymphatics provide particularly easy routes for permeation of the surrounding district. This is easy to demonstrate round the inguinal glands in melanotic sarcoma of the lower extremity. The fact has surgical importance. I have shown that in melanotic sarcoma, when the inguinal glands are removed, it is essential also to remove a surrounding circular area of the deep fascia.

Trunk-Permeation.

It is but rarely that permeation of the larger lymphatic vessels can be seen by the naked eye, but figure 2273 shows it beautifully in cancer of the bowel, and cases of permeation of the thoracic duct, though rare, are well recognised.

Trunk-permeation is a late event, since for a long time the lymph stream scours out the larger vessels. In the capillary lymphatics the feeble stream has no influence on the spread of permeation which proceeds as readily against the stream as with it. Before trunk-permeation occurs, the primary growth and the infected glands may be excised separately without incurring the penalty of recurrence. Later, a " monobloc " operation is essential to prevent recurrence in the line of the trunk lymphatics.

Lymph-Gland Embolism.

Before the process of permeation has extended very far from the primary growth some of the cancer-cells will project into the lumen of a trunk lymphatic, and a new factor comes into play. In the larger lymphatics the lymph stream is strong enough to sweep away the intruding cancer-cells. They are carried to the nearest lymphatic gland and deposited in its capsular sinus.

Lymph glands act for a considerable time as a barrier to the further spread of cancer-cells which reach them. The cancer-cells proliferate through the meshes of the gland, enlarging it and finally destroying its lymphatic structure. They finally reach the efferent lymphatics of the

Fig 2273.—Retrograde permeation of trunk lymphatics of the small intestine in cancer of the prostate The largest lymphatics are seen as white moniliform lines, the smaller ones as white networks upon the surface of the intestine The specimen *shows that the valves of* the lymphatic vessels are no obstacle to the spread of permeation against the lymph current.

(*By courtesy of Mr Cecil P G. Wakley. Museum, King's College Hospital.*)

gland and may permeate along these vessels to the next set of glands. Embolism at this stage is unlikely, since the stream of lymph through a gland must cease when it is choked by cancerous growth.

The high frequency of lymph-gland enlargement as the first clinical evidence of dissemination is a conclusive proof that the earlier and surgically important stage of the process takes place usually by way of the lymphatic system. This is confirmed by the fact that if a breast cancer is removed before the axillary glands are infected, about four cases out of five remain free from recurrence. The absence of remote deposits at the time when gland enlargement first declares itself shows that at this period spread by the blood stream is a negligible factor. Were this not so, the ablation of cancer would be a hopeless enterprise.

Retrograde Lymphatic Embolism.

Some authors have asserted that retrograde lymphatic embolism

is an important factor in dissemination. For instance, in breast cancer, when the homolateral axillary glands are blocked by growth, it is assumed that the lymph stream, setting towards the opposite breast, will carry cancer-cells to the opposite axillary glands. But the presence of valves in the trunk lymphatics will prevent reflux, and the fine anastomotic plexus of the middle line in any event acts as an effective filter which cancer-cells can only pass by permeation. I have shown that no outlying embolic foci can be found outside the microscopic growing edge of a breast cancer except in the glands.

By-pass Lymphatic Trunks.

Certain trunk lymphatics may pass by the first set of glands in their course, ultimately to reach glands more remote. Thus, some of the lymphatics of the forearm avoid the bicipital gland and run direct to the axillary glands. In a recent case of multiple X-ray cancer of the fingers, the bicipital gland was free from cancer-cells, which were, however, present in one of the axillary glands.

Invasion of a Gland often precedes Clinical Enlargement.

In the case just referred to, no enlarged glands could be felt prior to operation. It illustrates the validity of the surgical principle that except in growths known not to disseminate (rodent ulcer, lupus-carcinoma, and osteoclastoma) it is essential to cut the main line of dissemination by a complete removal of the regional glands, even if these glands appear clinically normal. If age and debility forbid this ideal course, a prolonged follow-up at short intervals is essential. The radium treatment of glands has hitherto not been so successful as to compete with their surgical removal. In certain carcinomata, e.g. of the lip and tongue, radium to the primary growth and surgical removal of the glands appears to be the method of choice.

In dealing with late or specially malignant growths it may be advisable to excise not only the regional glands, but also the set higher up. This is always advisable in melanotic sarcoma. For instance, if in this disease the axillary glands are enlarged, the supra-clavicular glands, even if not enlarged, should also be removed.

Gland Invasion from different Primary Sites.

It is impossible to deal in detail with glandular invasion from every site in which a growth may arise. Certain points of special surgical importance need a brief reference.

Carcinoma of the Breast.

As soon as lymphatic dissemination begins, the obstacles to permanent success after operation are formidable, owing to the rich and complex lymphatic connections of the breast.

Internal Mammary Gland Invasion.

Upon evidence that has never been challenged, the writer showed (*Surg., Gyn., and Obst.*, December 1927, 721) that when the axillary glands are invaded by growth there is a presumption that the internal mammary glands also are invaded. The two invasions are broadly simultaneous, but in carcinoma of the inner edge of the breast, that of the internal mammary glands may actually be the earlier. It may be inferred that in the average operation case of breast cancer with enlarged axillary glands the disease is already intra-thoracic. Fortunately, though the surgical removal of the internal mammary glands is hardly practicable, they can be dealt with by radium tubes introduced when the breast is removed, a procedure which, at the end of three years, shows an improvement of 10 per cent in the non-recurrence rate.

Apical Axillary Glands.

After operative clearance of the axilla it is very rare to see axillary recurrence, provided the clearance has been complete. Unfortunately, owing to their sheltered position, the apical glands of the axilla, lying upon the first digitation of the serratus magnus internal to the axillary vein and immediately below the clavicle, frequently escape removal. It is important to know that owing to a lymphatic trunk which pierces the great pectoral muscle to reach them directly, these glands may be infected before the lower glands of the axilla.

Aortic Gland Invasion.

After invasion of the internal mammary glands the next intra-thoracic glands to be attacked are the glands in the superior mediastinum on the arch of the aorta. This hopeless stage of thoracic invasion may have been reached in cases which appear operable. While the modern operation has almost abolished local recurrence, it cannot prevent the ultimate fatal evolution of deep latent foci within the chest.

If spread from the internal mammary glands to the glands on the arch of the aorta has occurred prior to operation, it is likely that a superior mediastinal tumour, with upper sternal dullness, dysphagia, dyspnœa, pleural and pulmonary deposits, and perhaps spinal metastases, will develop after a period of apparent health. This type of recurrence is due rather to the patient's procrastination than to any defect of surgical method. Even in such cases operation justifies itself by prolonging the patient's span of normal active life, and by averting the distress of external ulceration and lymphœdema of the arm.

Supra-clavicular Gland Invasion.

The first gland above the clavicle to show enlargement in breast cancer is situated in the lower and inner angle of the posterior triangle,

or behind the clavicle. This gland has connections both with the internal mammary glands and with the apical axillary glands. Subsequently, glands lying in the omo-hyoid triangle are involved, and next the glands

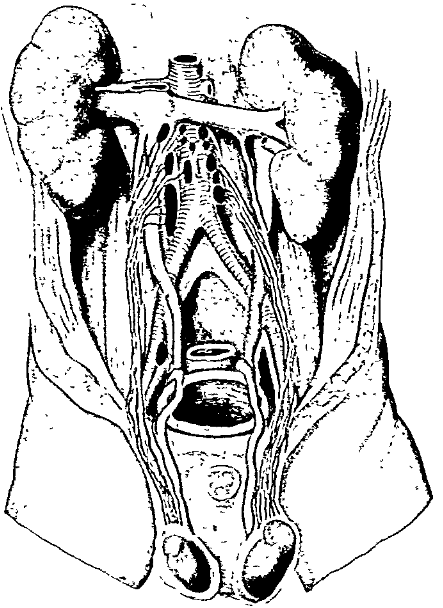


Fig. 2274.—The Lymphatics of the Testicle. ([illegible].)

of the main cervical lymphatic chain. Still later, a gland appears at the lower and inner angle of the posterior triangle of the opposite side. The evolution here repeats that on the homolateral side.

The early removal of enlarged supra-clavicular glands may avert recurrence for periods up to ten years, especially if combined with the

use of radium in the floor of the wound, and along the main cervical chain up to the base of the skull. I recently saw a case free from recurrence 22 years after such an operation.

Growths of the Testicle.

The descent of the testicle from its original position just below the kidney into the scrotum involves no change in its efferent lymphatics

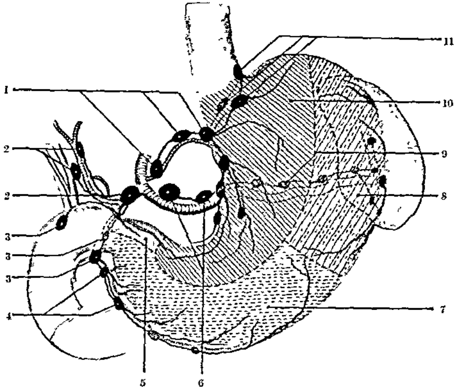


Fig 2275.—THE LYMPHATIC TERRITORIES OF THE STOMACH. (*Rouvière*)

1. Coronary chain.
2. Hepatic chain.
3. Pyloric group of glands.
4. Right gastro-epiploic glands.
5. *Pyloric zone of hepatic territory.*
6. Splenic chain.
7. Hepatic territory.
8. Splenic territory.
9. Splenic chain.
10. *Coronary territory.*
11. Cardiac glands.

except their elongation. They continue to drain into the aortic glands at the level of the renal veins (fig. 2274).

Consequently, lymph-gland enlargement in testicular growths must be sought for in the epigastric angle at about the level of the pancreas, where a deep homolateral induration may be palpable near the middle line.

The glands subsequently affected are those upwards along the œsophagus and perhaps at the root of the neck. Thus an enlarged gland in the omo-hyoid triangle may be the first clinical indication of an unobserved testicular growth.

It is not difficult to remove the lymphatic pedicle of the testicle

in the submaxillary glands, or if they arise further back, debouch directly into the tonsillar gland. One of the anterior marginal lymphatics runs to a gland of the main chain situated lower than the tonsillar gland.

(3) *Posterior,* arising from the region where the anterior pillar of the fauces joins the tongue, run either into the tonsillar gland, or into the submaxillary glands and thence to the tonsillar gland.

(4) *Central,* coming from the interior of the tongue.

Thus, as Poirier says, the efferent lymphatics of the tongue have a lower destination, the further forward in the tongue they arise. It is even

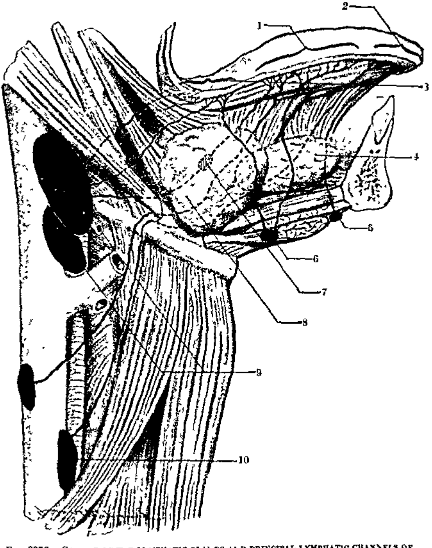


Fig. 2276. SCHEME OF THE LYMPHATIC GLANDS AND PRINCIPAL LYMPHATIC CHANNELS OF THE HEAD AND NECK. (*Rouvière.*)

1. Marginal vessels
2. Apical vessels
3. Posterior marginal vessels.
4. Sublingual salivary gland.
5. Submental gland.
6. Submaxillary lymphatic gland.
7. Lingual gland.
8. Submaxillary salivary gland.
9. Subdigastric (tonsillar) glands.
10. Sub-omo-hyoid gland.

through an external iliac incision up to the level of the renal veins, and the operation permits accurate radiation of the glands up to the diaphragm by implanted radium tubes on stout wires. In a recent case where I carried out this operation the highest gland removed was invaded by growth.

The testicle should be removed in one piece with the spermatic vessels and lymphatics. The vas deferens should be traced down into the pelvis and divided just above the bladder.

Stomach Cancer.

The lymphatic vessels of the mucosa of the stomach run to a rich subserous plexus, continuous over the whole stomach. From this plexus a series of lymphatic trunks concomitant with the gastric arteries arises and, according to the destination of these vessels, the stomach is divisible into three lymphatic regions, hepatic, splenic and coronary. The boundaries of these regions and the glands corresponding to them are indicated in H. Rouvière's diagram (fig. 2275). Cancer arising in the "splenic" area of the stomach has a better prognosis than cancer of the lesser curvature, apparently because its lymphatic connections are more restricted. It is probable that the use of buried radium tubes to deal with the glandular areas after gastrectomy would improve results. A study of figure 2275 will indicate how they should be placed.

Tongue Cancer.

It is important to know that the lymphatic vessels of the tongue decussate freely across the middle line. Jamieson and Dobson (*Brit. Journ. Surg.*, July 1920, 80) showed that only a very limited region of the tongue, namely the posterior two-thirds of the lateral margin, drains exclusively into the glands of the same side. For cancers arising anywhere else in the tongue, gland infection on both sides may be expected, and a bilateral gland operation is indicated.

The lymphatics from the various regions of the tongue, from its apex to its base, take a more or less parallel direction downwards and backwards, ultimately, after perhaps passing through intermediate glands, reaching the glands of the deep main cervical chain.

Poirier divides the collecting vessels of the tongue into four main groups (fig. 2276):

(1) *Apical*, two in number, one running direct to the sub-omo-hyoid gland low down in the main cervical chain, the other running to the submental gland.

(2) *Marginal*, coming from the lateral border and following the course either of the lingual artery or of the lingual vein, terminate

in the submaxillary glands, or if they arise further back, debouch directly into the tonsillar gland. One of the anterior marginal lymphatics runs to a gland of the main chain situated lower than the tonsillar gland.

(3) *Posterior*, arising from the region where the anterior pillar of the fauces joins the tongue, run either into the tonsillar gland, or into the submaxillary glands and thence to the tonsillar gland.

(4) *Central*, coming from the interior of the tongue.

Thus, as Poirier says, the efferent lymphatics of the tongue have a lower destination, the further forward in the tongue they arise. It is even

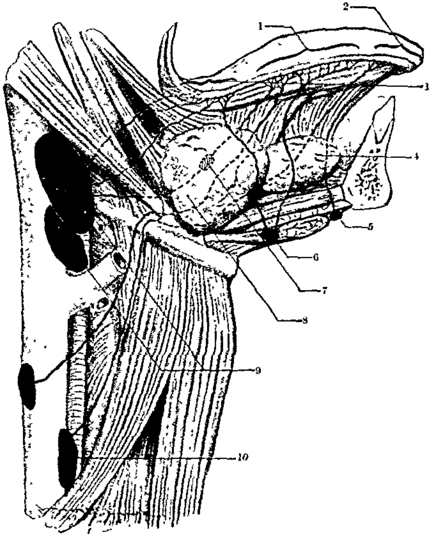


Fig 2276. SCHEME OF THE LYMPHATIC GLANDS AND PRINCIPAL LYMPHATIC CHANNELS OF THE HEAD AND NECK. (*Rouvière*.)

1. Marginal vessels.
2. Apical vessels.
3. Posterior marginal vessels.
4. Sublingual salivary gland.
5. Submental gland
6. Submaxillary lymphatic gland.
7. Lingual gland.
8. Submaxillary salivary gland.
9. Subdigastric (tonsillar) glands.
10. Sub-omo-hyoid gland.

more important to note that early tongue cancer may infect the main lymphatic chain from the digastric to the omo-hyoid (fig. 2277). The disease spreads rapidly along the glands of the main chain. Hence

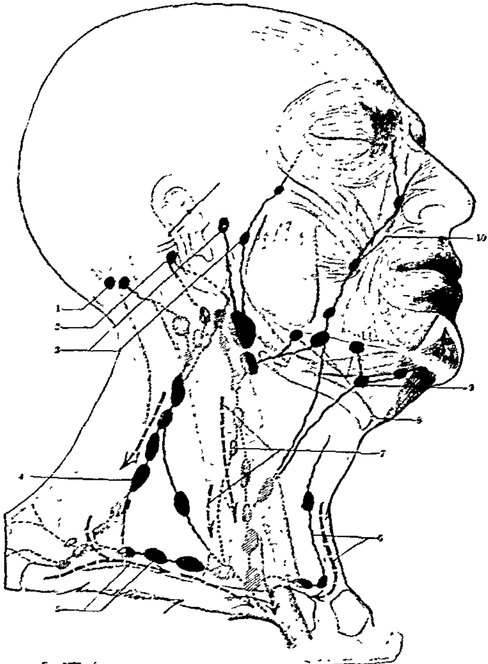
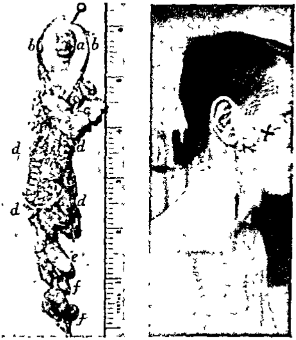


Fig. 2277.—Scheme of the lymphatic glands and channels of the neck. (Poirier.)

1. Occipital glands.
2. Mastoid gland.
3. Parotid glands.
4. Spinal accessory chain of lymph glands.
5. Transverse cervical chain of lymph glands.
6. Anterior jugular chain of lymph glands.
7. Deep cervical (internal jugular) chain of lymph glands.
8. Submaxillary lymph glands.
9. Submental gland.
10. Facial lymph glands.

a gland operation for cancer, as Butlin showed many years ago, must extend from the base of the skull to the sterno-clavicular joint, and must remove all the glands of the main chain and those of the submaxillary triangle. It may be unilateral only if the disease has begun in the posterior two-thirds of the lateral margin. The writer would add that, in his opinion, although the exposure of the internal jugular vein in its whole length is an essential preliminary of the operation, the removal of this vein and still more of the carotid artery is a gratuitous



A. B.

Fig. 2278.—A "MONOBLOC" OPERATION FOR RECURRENT MELANOTIC SARCOMA OF THE CHEEK. THE GROWTH BEGAN AT THE POINT MARKED WITH A CROSS IN THE SECOND FIGURE. NO GLANDS COULD BE FELT BEFORE OPERATION. THE PATIENT REMAINS WELL A YEAR LATER. (*Author's case.*)

A. The specimen (*a*) The primary growth surrounded by an area of skin (*bb*) into which it shows signs of spreading; (*c*) a portion of the buccinator pad of fat, (*dd*) subcutaneous fat and parotid fascia containing small infected glands, (*e*) tonsillar gland, black at its upper pole, (*ff*) infected glands of the main deep cervical chain B The patient after operation, showing the scar

(*Photographs by Miss D. Clephane.*)

complication of the operation which aggravates its risks without improving its results.

Growths on the Cheek.

A recent case of melanotic sarcoma of the middle of the cheek may be taken as illustrating lymphatic spread from this situation. No enlarged glands could be felt before operation, but the operation disclosed black glands beneath the parotid fascia, in the pre-auricular region, and in the submaxillary triangle. The tonsillar gland was much enlarged, and from this gland infection had spread up and down the main lymphatic chain of the neck as high as the base of the skull, and down to the omo-hyoid.

The primary growth, its efferent lymphatics and the glands were removed in one piece by a troublesome dissection (fig. 2278) which necessarily divided some of the branches of the facial nerve. A year later the patient shows no sign of recurrence.

Rectal Growths.

Growths beginning in the anal canal below the white line, which is formed by an invagination of the skin, metastasise to the inguinal glands, usually of both sides. Rectal growths higher up first cause enlargement of the glands in the mesorectum as high as the promontory. Later, the internal or external iliac glands and the aortic glands may enlarge. Still later, by way of communicating lymphatics through the inguinal canal, the inguinal glands may be infected.

Lymphœdema in Cancer.

The blocking by permeation of large areas of the lymphatic system in cancer often leads to a lymphatic œdema of the skin (*peau d'orange*), sometimes to a massive œdema of a whole limb (*brawny arm*), and

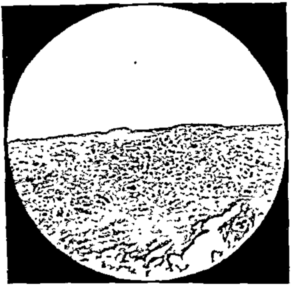


Fig. 2279.—Permeation of the subpleural lymphatic plexus (so-called lymphangitis carcinomatosa).

sometimes to a serous effusion in the pleura or peritoneum. Serous effusions appear to be the result of permeation of the subserous lymphatic plexuses by which, normally, excess serous fluid is absorbed (fig. 2279). Ascites and pleural effusion are frequent immediate causes of death in cancer.

Pressure of growth masses on veins, by increasing transudation, may aggravate lymphatic œdema. Lymphœdema does not necessarily mean that the œdematous tissue contains cancer-cells, it only implies that permeation has blocked the lymphatics somewhere between the œdematous area and the glands into which it drains.

The Relative Share of the Hæmic and Lymphatic Systems in Dissemination.

There is no doubt that cancer may spread either by the lymphatics or

by the blood stream. Naked-eye demonstration of this statement is afforded by the exceptional cases in which the inferior vena cava, or the thoracic duct, may be found plugged by growth. But in carcinoma and in melanotic sarcoma, and possibly in other sarcomata, the main highway of the disease until it is far advanced is certainly the lymphatic system, partly because access to the blood stream is more difficult, but mainly because healthy blood is a medium hostile to the life of epithelium, exciting an organising thrombosis which destroys the cancer-cells.

In the last stages of the disease the resistance of the blood to colonisation by cancer-cells may break down. Thus R. Volk described a case of gastric carcinoma which had invaded the liver. Cancerous pulmonary embolism had occurred, and daughter-nodules were found in the kidneys, in the brain, and upon atheromatous ulcers in the abdominal aorta.

Local Invasion of the Blood-Vessels in the Primary Growth.

In certain sarcomata the blood-vessels, often thin-walled and rudimentary, lie embedded in a mass of neoplastic cells, and local invasion of the blood stream must occur early, but dissemination in sarcoma has not been accurately studied, save in melanotic sarcoma, a subject which will be dealt with later.

In rare and exceptional cases of breast cancer Delbet and Mendaro have demonstrated local invasion of the blood-capillaries. In the aged, breast cancer may exceptionally first manifest itself by the sudden appearance of a hæmatoma in the breast, a proof of the erosion of blood-vessels by the growth. Such cases, however, do not at this stage present evidence of widespread dissemination. Dissemination to the bones in advanced breast cancer, without any glandular enlargement, is not unknown.

Destruction of Cancerous Emboli in the Blood Stream.

M. B. Schmidt in forty-one cases of abdominal malignant disease found fifteen cases in which cancerous emboli were present in the lungs. In seven of the fifteen cases no macroscopic deposits were found in the lungs or liver, or in the course of the systemic circulation. Only three cases showed deposits in the lungs visible to the naked eye. It may be inferred either that the embolism only occurred just before death, or that the emboli were, as a rule, destroyed promptly after reaching the blood stream. Schmidt states definitely that most of the emboli are destroyed by organisation of their ensheathing thrombus, or are encapsuled and rendered harmless.

Goldmann found that when the wall of a vein is infiltrated by

growth a protective thrombosis may occur within the vein. He also showed that invasion of the veins near the primary growth might occur in cases which were found post mortem to present no metastases.

It thus appears that invasion of the blood stream in malignant growths, though it may be frequent, is usually late and ineffective, except perhaps in some sarcomata.

Of late there has been a tendency to hark back to the embolic theory of dissemination. R. A. Willis (*The Spread of Tumours in the Human Body*, J. and A. Churchill, 1934) has recently stressed the importance of blood dissemination, basing his views on the examination of portions of tissue selected as suspicious at necropsy, and has brought forward new and interesting evidence. He found evidence of blood dissemination in 15 per cent of cases. But random sampling of the tissues cannot determine the relative shares of the blood and lymph systems in dissemination. It is necessary to adopt microscopic methods on a macroscopic scale, and to examine long strips of tissue extending radially from the primary growth into the surrounding tissues. Using this method I have shown that lymphatic permeation is the main agent in the earlier stages of dissemination. Whereas cancer-cells in a blood-vessel excite a thrombotic reaction which usually destroys them, cancer-cells in a lymphatic produce no visible reaction. It is only when the lymphatic has become distended by the growth within it that round-celled infiltration and other signs of inflammatory reaction are manifested around it.

Distribution of the Secondary Deposits.

If cancer is distributed by the blood stream, the cancer emboli should lodge by choice in the terminal arteries, especially at the extremities of the limbs, and should affect with equal frequency the side on which the growth originates and the opposite side of the body. Invasion of the lungs, in which the emboli must lodge before they can reach the systemic circulation, should be more frequent than that of the other viscera. A general outburst of metastases at widely different points all over the body should follow the infection of the blood stream.

This is not the picture of cancerous dissemination. The process clinically begins by the embolic invasion of the nearest set of lymphatic glands—clear evidence that the disease is using the lymphatic channels. Next, secondary nodules appear—always in the immediate neighbourhood of the primary growth. In the subcutaneous tissue the nodules spread in a centrifugal manner away from the primary growth, involving a gradually increasing circular area centred upon it. In exceptional cases this circular area may extend up to the scalp, down below the

groins, and as far as the middle of the humerus, but the forearms and legs are almost invariably free, though they are election sites for non-cancerous embolism. So too, the bones below the elbow and the knee are only very rarely the sites of secondary deposits. The proximal ends of the humerus and femur are invaded more frequently than the distal ends. Piney has attempted, though unconvincingly, to explain this difference as due to the persistence of red marrow in the proximal, but not in the distal ends of these bones. Willis stresses the importance of local differences of " soil " for the incipient metastases as determining metastatic distribution.

Transcœlomic Implantation.

The slow spread of permeation ultimately carries cancer-cells either to the subpleural or the subperitoneal lymphatic plexus. Shortly afterwards, by erosion or rupture of the permeated subserous lymphatics, cancer-cells escape into the serous cavity. From this moment events march with rapidity to a fatal end. The cancer-cells distribute themselves widely through the serous cavity under the influence of gravity and of visceral movement. They attack the viscera which are in relation to the serous membrane, and soon visceral deposits manifest themselves. Prognosis, hitherto obscure, now becomes easy—death within a year.

In rarer cases, invasion of the cranial cavity either by permeation upwards along the main deep cervical chain of lymphatics, or by blood embolism, may terminate the case.

Bone Deposits in Cancer.

In 1906 an examination of the bone deposits in 329 cases of breast cancer led me to question the doctrine that such deposits arise from blood dissemination. It appeared that in general the liability of a bone to cancerous deposit increases with its proximity to the site of the primary growth, and that the bones distal to the knee and elbow escape invasion except in the rarest instances.

The point of invasion of the femur was found to be the base of the great trochanter, that of invasion of the humerus the deltoid insertion. These are subcutaneous areas where the bone is in close contact with the fascial plexus, which, as we have seen, is the main highway of parietal permeation. It appeared highly probable, therefore, that the centrifugal spread of permeation through the fascial plexus was the agency which carried infection to these bones. The conclusion was supported by the observation that out of eight cases in which only one femur was affected by growth, the disease was on the same side as the primary breast growth in six cases. Such a preference for the side of the primary

growth, when considered in connection with the almost universal escape of the distal bones of the limbs, seemed quite inconsistent with such a process as blood embolism which would affect impartially both sides of the body, and would for choice attack the distal portions of the limbs, where non-cancerous emboli often lodge. Spontaneous fracture of the humerus, it is true, seemed to be more frequent on the contralateral side, but this might be accounted for, as a rule, by the surgical clearance of the axilla on the side of the growth.

It was not difficult to apply the permeation theory to other bone deposits, and deposits in the cranial bones can be explained by the extension upwards along the lymphatic vessels of the deep cervical chain. Similarly, permeation along the lymphatic vessels of the intercostal spaces to the glands which lie upon the necks of the ribs will account for deposits in the thoracic vertebræ, and particularly for the special incidence of such deposits upon the upper thoracic vertebræ (third to sixth) which Carnett has recently demonstrated. The corresponding intercostal spaces are in specially close relation to the breast.

Carnett and Howell ("Bone Metastases in Cancer of the Breast," *Ann. Surg.*, June 1930, 811), in 204 advanced cases of breast cancer submitted to X-ray examination during life, found bone deposits in 49·5 per cent. Secondaries in bone are a late development, usually occurring two years or more after the onset of symptoms. Thus they are not seen in the more rapid type of carcinoma. The arrest of local manifestations of disease by efficient operation has of late years increased the number of those who survive to die of bone deposits.

In early cases of bone invasion, Carnett finds that, apart from direct extension to ribs underlying the breast lesion, the order of frequency is: (1) the homolateral shoulder-girdle (head of humerus and glenoid region of the scapula); (2) the third to the sixth thoracic vertebræ; and (3) the upper lumbar vertebræ.

In 54 cases of metastasis to the shoulder-girdle the deposits were bilateral in 24, homolateral in 23, and contralateral in only 7. Studies of the humerus revealed a gradually progressive extension of the disease downwards in the bone. In only 6 cases were deposits present below the elbow, usually first in the head of the radius. Metastasis then spreads downwards in the radius and ulna and may involve practically the whole length of these bones. Deposits may appear in the bones of the hand if all three long bones of the arm are extensively involved, but not otherwise. A similar downward progress of the disease is traced in the lower extremity, where the deposits begin in the femoral head and

the acetabulum. In only two cases of their series of 101 cases did Carnett find it necessary to attribute the metastases to blood embolism.

Carnett was the first to point out the importance of permeation along the deeper lymphatic chains, such as those within the abdomen, or along the intercostal spaces, for the genesis of bone deposits. He draws attention to the great frequency of cancerous invasion of the aortic and iliac glands, often in the absence of any enlargement of the inguinal glands. Around such glands he often demonstrated permeated lymphatics. Secondary permeation around the glands leads to the invasion of the lumbar vertebræ, lower ribs and pelvis.

Piney has attempted to account for the peculiar distribution of metastatic tumours in bones in another way. He states that red marrow disappears from most of the bones in adult life, but that it persists in the upper end of the femur and the upper end of the humerus,

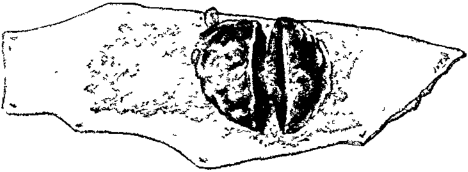


Fig. 2280.—A melanotic sarcoma of the skin pedunculated and partly bisected The skin around shows a brown discolouration due to the lymphatic spread of the growth.

(*Museum, Middlesex Hospital.*)

and forms a favourable nidus for carcinoma cells. Willis elaborates the hypothesis by assuming that, if carcinoma destroys the red marrow in the proximal end of the bones, a compensatory development of red marrow may occur lower in the bone, so that the disease is able to spread centrifugally down it. These explanations do not carry conviction. (Piney, *Brit. Journ. Surg.*, 1922, X, 235.)

At present the weight of evidence seems to point to the conclusion that carcinoma is usually carried to bones by lymphatic channels, but occasionally by the blood stream. Controversy will continue until further evidence is produced.

Dissemination of Melanotic Sarcoma.

The black pigment of melanotic sarcoma (and that the growth is a sarcoma, not a carcinoma, was many years ago established by Ribbert) enables its spread to be traced with accuracy and with relative ease. The available evidence shows that the earlier stages of dissemination are brought about by lymphatic permeation and lymphatic embolism.

In the later stages, blood dissemination is superimposed upon lymphatic dissemination, but fortunately not at such an early date that the success of timely operative intervention is excluded. The average duration of melanotic sarcoma from the time of onset to death is three years, and *the disease is not so intensively malignant as it is reputed to be.* The usual operative treatment of the disease, even at the present day, is *irrational and inadequate, and accordingly unsuccessful.*

The progress of melanotic sarcoma is best followed by taking a secondary focus of the disease in a superficial lymphatic gland, and by examining a long radial strip of the tissues around the infected gland. Around the gland, secondary cutaneous nodules appear and spread away from it in a centrifugal manner. It may be inferred that a process of local centrifugal spread, independent of the "set" of the lymph current, takes place round the gland as a focus. Microscopic examination shows that permeation of the lymphatics is the primary process concerned, and that it occurs first and principally in the plane of the fascial lymphatic plexus. Permeation is found in the plane of the deep fascia beyond the region of visible nodules, and where neither the muscle, the subcutaneous fat nor the skin is invaded. In the end of the strip near to the gland, upstream permeation of the cutaneous and muscular tributaries of the fascial plexus produces nodules in the skin and muscle. Here, too, it is seen that, owing to the concomitance of lymphatics and blood-vessels, rupture of a permeated lymphatic leads to the enveloping of the associated artery and vein in a sheath of cells, which infiltrate the walls of the blood-vessels and finally enter the lumen, at first, of the thin-walled veins and, later, of the arteries. It is at this point that lymphatic dissemination becomes of secondary importance. The interested reader will find more detail in my lectures on "The Pathology of Melanotic Growths" (*Lancet*, April 6th and 13th, 1907).

Embolic distribution of the growth by the blood leads to widespread visceral metastases. Melanuria, always a late symptom, may occur from embolism of the renal glomeruli.

But even at the time of death it is the rule that the secondary deposits are much more abundant on the side of the body on which the tumour originated. This fact shows that the earlier stages of dissemination are due to local (lymphatic) spread. In rare cases after death practically all the lymph glands of the chest and abdomen may be enlarged by secondary deposits while the viscera are almost free of nodules which could be ascribed to blood embolism. Probably, therefore, as in carcinoma, the blood may exert a destructive effect upon the cells of melanotic sarcoma.

Blood Dissemination a Late Event.

Though blood dissemination is almost invariable in melanotic sarcoma it is fortunately late. This is shown by microscopic evidence, by the long average duration of the disease, and by the occasional success of rational operative treatment, even in recurrent cases with heavily infected glands. A patient with a recurrent melanotic sarcoma of the upper arm, operated upon by a "monobloc" operation when the axillary glands were already much enlarged, died eighteen years later without recurrence. Figure 2278 shows that the "monobloc" operation is possible even in such a difficult situation as the face.

CHAPTER V

Elephantiasis

by

Philip Manson-Bahr

Elephantiasis is a condition in which the lymphatic tissues mostly are concerned, and it may be defined as a progressive histopathological state characterised by fibrosis and hyperplasia of the dermis and subdermal tissues.

Since early times it has been noted that elephantiasis is more common in the tropics than in the temperate countries, and though the cause of the tropical form is now known to be the filaria (*Wüchereria bancrofti*), yet elephantiasis with indistinguishable clinical features is found all over the world.

It is necessary at the outset to distinguish elephantiasis from lymphatic œdema, which is a condition of solid œdema without hypertrophy.

The term *Elephantiasis nostras* has been generally applied to the non-parasitic form in order to distinguish it from filarial elephantiasis (formerly known as *E. arabum*).

CLASSIFICATION

In the rather incomplete state of our present knowledge it is difficult to find an entirely satisfactory classification. The following, however, is based upon the classification adopted by Bertwistle and Gregg (1928):

1. *Congenital.* A condition first described by Milroy and Meige in which there appears to be an hereditary maldevelopment of the lymphatic vessels and tissues which manifests itself as œdema. Apparently two types can be distinguished, simple and familial.

Simple congenital lymphœdema affects single individuals in a family; *familial* congenital lymphœdema affects a sufficient number of blood relatives to suggest an hereditary disposition. This condition is sometimes described in medical text-books as "hereditary trophœdema."

2. *Traumatic.* Under this heading those cases of elephantiasis are included which result from extensive destruction of glands, and which

are usually associated with cicatricial contraction of the connective tissues. This has been recorded as the result of removal of tuberculous inguinal glands, and as the result of infection with the virus of *lymphogranuloma inguinale* (climatic bubo).

It is also recorded that in former years excision of enlarged inguinal glands was practised on recruits for the army in order to enable them to pass the medical tests, and in some cases elephantiasis of the legs or genitals resulted.

3. *Infective.* A number of micro-organisms and parasites which affect the lymphatic glands and vessels are included under this heading:

(*a*) *Filarial Elephantiasis. Wuchereria bancrofti* (*Filaria bancrofti*) is by far the most frequent and is found in most tropical countries, being especially abundant in India, China and Polynesia. In this condition the adult worms of both sexes live in the lymphatic system, and the embryos emitted by the females pass via the lymphatic vessels and glands into the blood stream.

Patients infected with this filaria are especially liable to superimposed *septic infections*, and these may play a part in the ultimate blockage of lymphatic tissues. It is now, however, generally held that the effects of the filaria alone are sufficient to cause extensive lymph stasis.

Similar elephantoid conditions are sometimes caused by a filaria worm of another genus —*Onchocerca volvulus*.

(*b*) *Tuberculous.* Tuberculous infection of lymphatic glands and tissues is well known, and in chronic ulceration of the groin glands in lupus of the skin with concomitant infection of the lymphatic vessels, an elephantoid condition of the limb may supervene as in the case described by J. A. White (1924).

(*c*) *Spirochætal.* In long-standing syphilitic gummatous ulceration of the thigh, and in the analogous case of yaws associated with fibrosis and cicatricial contractures, lymph stasis and elephantiasis may supervene.

(*d*) *Leprotic.* Elephantoid thickening of the skin and subcutaneous tissues frequently supervenes in chronic leprosy, and is undoubtedly due to direct infection of the lymphatic vessels with the leprosy bacillus.

(*e*) *Granulomatous.* In the condition known as *Granuloma venereum*, which is a particularly chronic ulcerating disease affecting the tissues of the groin, the main lymphatic vessels may be involved and lymph stasis may supervene. The same process may occur in *lymphogranuloma inguinale* (or climatic bubo), which is caused by a virus with special affinity for the lymphatic system.

(*f*) *Malignant.* It is well known that lymphatic spread of carcinoma, especially of the more chronic and slow-growing varieties, may rarely cause lymphatic hyperplasia.

(*g*) *Bacterial.* Streptococcal and staphylococcal infection of the lymphatics following upon some septic abrasion of the foot or leg is undoubtedly a *not-infrequent cause of elephantiasis of the* lower limbs. The elephantoid state is preceded by frequent and violent attacks of septic lymphangitis, in which the streptococcus can usually be demonstrated. This condition may sometimes supervene upon surgical operations upon the legs.

(*h*) *Toxic.* Apparently, rarely, chronic absorption via the lymphatics of some irritating toxin may cause such destruction of lymphatic tissue as to produce an elephantoid condition indistinguishable from filarial elephantiasis. The writer in 1920 described a case of elephantiasis of the scrotum in a man of sixty years of age who for thirty years had treated a large patch of psoriasis on the left buttock with daily inunctions of chrysarobin. The urine contained a cloud of albumen and renal cells.

GENERAL CONSIDERATIONS ON LYMPH STASIS

Views upon the mechanism of production of lymph stasis and lymphatic hyperplasia have been considerably altered by recent work. It was formerly considered necessary that, in order to obtain complete lymph stasis, blockage of one or more of the main venous trunks must be produced, and it was thought that the mechanism of lymphœdema in man differed from that in experimental animals. Drinker and Field (1934) have, however, brought about true elephantiasis in the legs of dogs by centripetal injection of irritants into the lymphatic trunks. At first they produced this effect by injecting 2–4 cc. of a watery suspension of crystalline silica into a lymphatic, followed by the same quantity of a 2·5 per cent watery solution of quinine hydrochloride. The silica causes the proliferation of the endothelium of the lymphatic vessel, whilst the quinine acts as the sclerosing agent.

Furthermore, these workers demonstrated that the limbs of the experimental animals showed enormous dilatation of the tissue spaces with a fluid rich in proteins, the albumen : globulin ratio being the same as that of the plasma.

After the appearance of the elephantiasis, the tissues are attacked by an acute generalised superficial inflammation due to a hæmolytic streptococcus. Recently, similar results of complete lymph blockage have been obtained by the gradual infiltration of indian ink. It is

therefore seen that there is striking analogy between the experimental elephantiasis produced in dogs and the natural disease as it appears in man.

PHYSIOLOGICAL CONSIDERATIONS

Lymph is usually regarded as a transudate from the veins—indeed, lymphatic vessels themselves are in reality modified veins in which the endothelium, when once formed, retains specific characters.

The work of Drinker and his colleagues goes to show that vascular endothelium permits salts, electrolytes and proteins to pass through it into the tissue spaces. These latter return to the blood-plasma through the vascular endothelium, whilst the proteins are absorbed into the lymph stream by the lymphatic endothelium.

The thesis formulated by Starling in 1896 still holds good, namely, that the balance between the osmotic pressure of the plasma proteins and the capillary blood-pressure is the underlying mechanism regulating the movement of water across the capillary wall. That there is an intimate relationship between venous pressure and lymph production is seen when, after pressure is raised in the lobular capillaries of the liver, an immediate outpouring of highly proteinised lymph from the thoracic duct occurs.

It has also been recorded in some cases of slowly developing cirrhosis of the liver, that an extensive varicosity of the lymphatics of the abdominal wall and solid lymphœdema of both legs may ensue.

It appears that, in order to produce the true elephantoid state, there must be a transudation of lymph and that this transuded lymph must contain an excess of protein, such as occurs when a lymphous exudate collects as the result of the inflammation, and this, in turn, acts as a cell stimulant so as to produce lymphatic hypertrophy and hyperplasia, for it forms an ideal culture medium for proliferating cells.

Superficial lymphatic capillaries are specially abundant and contain actively circulating lymph which continues to flow, even when the limb is at rest, and it has further been ascertained that the flow from the forearm to the axilla is very rapid, and that material introduced into the forearm reaches the axillary glands in less than ten minutes. Furthermore, Woollard and Gray have shown that material injected into the great toe may be present in the large lymphatic trunks above the ankle in two minutes and that it travels via the lymphatic capillaries.

The lymph stream has a well-defined series of directions of flow from different areas of skin with sharp lines of demarcation between them. The discovery of these delimited areas shows that the former

conception of a generalised lymphatic anastomosis is incorrect, and this fact must therefore be taken into account in planning surgical operative measures.

The superficial lymphatics are the most important and extensive part of the lymphatic system, so that the tissue changes following lymphatic obstruction are more pronounced in the *integument and* subcutaneous tissues, and little hypertrophy occurs in the deeper tissues. *Woollard and Gray*[1] *have shown that the lymphatic supply* of the skin is particularly rich, and that the vessels lie mainly in the superficial part of the dermis placed at a slightly deeper plane than the arterioles which give off loops to the dermal papillæ. There is a wide-meshed plexus of fairly straight vessels, each of great length compared to their lumen, lying parallel to the skin surface, and these vessels contain no valves.

In the deeper layers the lymphatics form a series of collecting radicles rather than a true plexus, but they are joined to the superficial plexus by more or less vertically placed vessels. The collecting trunks possess valves situated about 1 mm. apart.

The lymphatics of the subcutaneous tissue are large drainage trunks which have no association with the larger subcutaneous veins. There is therefore a clear separation of the superficial, or external, lymphatic system from the deep, or internal, system with the deep fascia intervening as a boundary between them. *The deep fascia is devoid of lymphatics.*

THE PATHOLOGY OF CONGENITAL LYMPHŒDEMA

Comparatively little work has been done on the pathology of this obscure disease, and this for the most part on tissues removed at operation. On microscopic examination the skin and deep fascia appear normal; but the distance between the two is greater than in *normal tissues. The outstanding appearance is that of a sponge.* The fibrous tissue contains numerous widely dilated lymph spaces which are seen in the septa and corium as well. The microscopic appearance of these tissues is characteristic. The predominant feature is the replacement of adipose tissue by enlarged lymphatic spaces surrounded by loosely woven connective tissue.

Congenital lymphœdema is therefore characterised by the replacement of the normal subcutaneous fat by widely dilated lymph spaces and by fibrous tissue.

Possibly the increased surface area occupied by lymphatic vessels

[1] Woollard (H. H.) and Gray (J. H.). The author acknowledges his indebtedness for their permission to refer to their hitherto unpublished researches.

creates a state tending to produce lymph stasis, which results in fibrosis, as lymph constitutes such a good culture medium for fibroblasts. This lymphangiectasis may therefore be viewed as a developmental anomaly.

THE PATHOLOGY OF FILARIAL ELEPHANTIASIS

A consideration of the mechanism of the production of tropical elephantiasis entails a study of the natural history of *Wüchereria bancrofti*. These parasites are long hair-like transparent nematodes possessing a chitinous cuticle (fig. 2281). The sexes are found generally coiled together in the lymphatic vessels and glands; when they inhabit the latter, as O'Connor has shown, the parasites are found in the afferent lymphatic vessels and in the cortical sinuses.

Fig. 2281.—W. BANCROFTI (NATURAL SIZE). A. MALE. B. FEMALE. (*Manson's "Tropical Diseases."*)

The *male* is 40 mm. in length by 0·1 mm. in breadth, and is distinguished from the female by the small size and the corkscrew-like tail. The *female* measures 65–100 mm. in length by 0·28 mm. in breadth. The ova in the upper portion of the uterus contain well-formed embryos enclosed in a membrane which subsequently becomes the sheath of the embryonic filaria (or microfilaria) as it appears in the blood stream.

These embryos (microfilariæ) (fig. 2282) emitted by the viviparous female filaria pass with ease and without injury through the lymphatics and lymphatic glands (Drinker, Augustine and Leigh, 1935).

Eventually they gain the blood stream and appear in the blood. Whether they do so via the thoracic duct, as has been so frequently stated, is a moot point, as it has been shown by Augustine and Drinker (1935) that microfilariæ can readily leave the circulation and enter lymphatic vessels by their own volition.

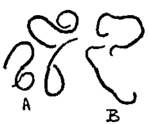


Fig. 2282.—DISTINGUISHING FEATURES OF MICROFILARIA BANCROFTI AND MICROFILARIA LOA, IN STAINED SPECIMENS. ATTITUDES (A) OF MICROFILARIA BANCROFTI, (B) OF MICROFILARIA LOA. (*Manson's "Tropical Diseases."*)

The adult filariae during life appear to cause but little destruction to the tissues they inhabit, beyond causing local fibrotic thickening of the vessel wall, but where the tissues have been previously damaged, the migration of the embryos emitted by the parent filaria becomes impeded and the microfilariæ become imprisoned by the proliferation of the lymphatic endothelium, as the writer originally demonstrated, and as has been exemplified by O'Connor's recent work.

When the mature worm dies, it becomes cretified and continues to act as a tissue irritant and lies, like a mummy, in the lymphatic glands and vessels surrounded by a sarcophagus of inflammatory tissue (fig. 2283).

The writer originally showed in 1912, a fact abundantly confirmed by O'Connor (1931), that by repeated infection with adult filariæ a condition of hyperfilariation is produced in which all the main lymph channels (say, of the groin) are blocked by cretified filariæ and the lymphatic fibrosis they bring about, whilst the function of the

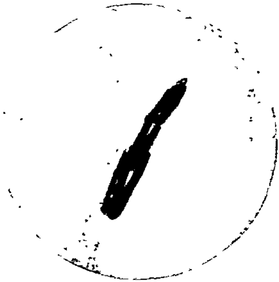


Fig. 2283.—Microphotograph.
(P. Manson-Bahr)

lymphatic glands is destroyed by fibrosis and giant-cell proliferation, and thus complete occlusion of the lymph channels is brought about.

Thus the pathology of lymph hyperplasia in filarial elephantiasis may be satisfactorily explained on the known pathology of filarial disease. That it is a central blockage and that it acts essentially in much the same manner as in hereditary lymphœdema, there can hardly be any reasonable doubt (O'Connor, Golden, Ross and Auchincloss).

In the pathologically-produced elephantoid tissue the cretified remains of dead adult filariæ can be demonstrated by X-ray examination (Golden and Auchincloss). Furthermore, O'Connor has shown that the periodic attacks of inflammation in tropical elephantiasis or lymphangitis arise from "focal spots" which are foci of a low form of suppuration containing the remains of dead filariæ in elephantoid tissue.

There is one aspect which has been the subject of much speculation, namely, the frequent absence of the characteristic microfilariæ in the

blood of victims of elephantiasis. The answer surely is that the existence of such a large area of lymph blockage precludes the entry into the blood stream of microfilariæ from that lymph area. Consequently there is a lesser likelihood of the parent filariæ procuring an unobstructed passage into the blood for their embryonic young.

THE CLINICAL FEATURES OF FILARIAL ELEPHANTIASIS

Filarial elephantiasis, when fully developed, is so characteristic as not to warrant any particular description. It usually occurs in an

Fig 2284.—ELEPHANTIASIS OF THE SCROTUM, SHOWING THE SCAR OF A HEALED ABSCESS. (*Photograph by P. Manson-Bahr.*)

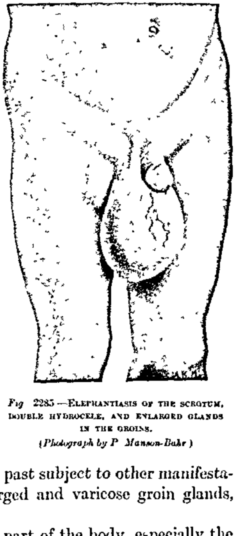


Fig 2285.—ELEPHANTIASIS OF THE SCROTUM, DOUBLE HYDROCELE, AND ENLARGED GLANDS IN THE GROINS. (*Photograph by P. Manson-Bahr.*)

individual who has been for some time past subject to other manifestations of filarial disease, such as enlarged and varicose groin glands, hydrocele, chyluria, etc.

This elephantiasis may attack any part of the body, especially the legs, scrotum (figs. 2284 and 2285) and penis in the male, the vulva in the female, the arms (fig. 2286 and 2287) and the mammæ (fig. 2288).

More rarely, localised and pedunculated forms of elephantiasis have been reported on the scalp, face, buttocks, thighs and other parts of the body.

The subjoined table is made from statistics of 4712 cases collected by Stephens and Yorke:

RELATIVE FREQUENCY OF PARTS ATTACKED.

Legs.	Scrotum.	Arms.	Legs and Scrotum.	Legs and Arms.	Legs, Arms and Scrotum.	Breasts.
57%	35%	0·9%	0·9%	3·5%	0·8%	0·1%

It is to be noted that involvement of more than one part such as the legs and scrotum is less frequent, but the parts affected vary much in different countries. In the Pacific form of filariasis (the non-periodic *W. bancrofti*) the arms are more frequently attacked than in other parts

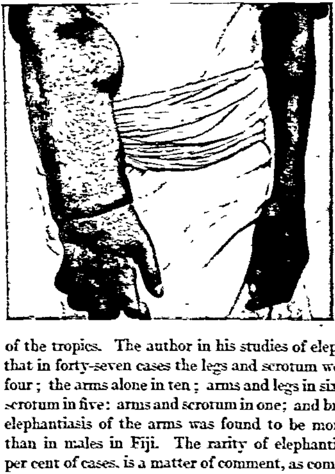


Fig. [illegible].—ELEPHANTIASIS OF RIGHT ARM IN A FIJIAN. (*Photograph by P. Manson-Bahr.*)

of the tropics. The author in his studies of elephantiasis in Fiji noted that in forty-seven cases the legs and scrotum were affected in twenty-four; the arms alone in ten; arms and legs in six; both arms, legs and scrotum in five; arms and scrotum in one; and breast in one. Curiously, elephantiasis of the arms was found to be more common in females than in males in Fiji. The rarity of elephantiasis of the vulva, 0·8 per cent of cases, is a matter of comment, as compared to the frequency of elephantiasis scroti in the male. This is possibly explained partially by natural reticence on the part of the sufferers to exhibit these parts. It is possible, too, that the rather more abundant lymphatic supply of these parts in the female militates against complete blockage. Enlargement of the lymphatic glands draining the area is an almost invariable accompaniment of elephantiasis. In the case of the leg it is the inguinal

glands, and in the case of the forearm the epitrochlear. In 1912 the author showed that enlarged epitrochlear glands, often of considerable size and very common amongst the Fijians, form prominent and noticeable tumours and are usually the precursors of elephantiasis of the forearm. When excised, numerous adult filariæ can usually de demon-

Fig. 2287.—Elephantiasis of both arms and left leg in a Samoan

(*Photograph by Prof P A. Buxton*)

Fig. 2288.—Elephantiasis of mammæ, left leg and foot also affected.

(*Photograph by Dr Davies, Samoa*)

strated in the sinuses of the gland. These baggy lymphatic swellings containing enlarged glands are usually observed above the internal condyles in elephantiasis of the upper extremities. This has been confirmed by Professor P. A. Buxton in Samoa.

CLINICAL PECULIARITIES

The onset of true elephantiasis may be painless and gradual, accompanied by a gradually developing œdema. On the other hand, the

actual commencement usually dates from the first attack of *lymphangitis*. This is usually sudden, and manifests itself by an erysipeloid attack accompanied by a rigor, pyrexia, vomiting and body pains. The attacks recur at regular intervals, and after each the lymphatic œdema becomes more pronounced and is consequently of longer duration.

The process of the disease varies considerably in various cases.

During the *first* stage there is uniform swelling and thickening of the part. The overlying skin is smooth, pale, and cool.

During the *second* stage the skin becomes coarser and more thickened and acquires an uneven ridged appearance, and this usually coincides with some hypertrophy of the adjacent muscles.

In the *third*, or fully developed stage, the skin and subcutaneous tissues become greatly hypertrophied and, in the case of the lower limb, there are considerable folds separated by deep sulci, occurring mostly at the folds, whilst in the case of the scrotum there is a diffuse ruggedness. The skin may become studded with bosses, numerous wart-like projections (*E. verrucosa*), or fissures, whilst ulcers or abscesses may form. When the ankle and foot are swollen and the toes unaffected, the peculiar "tortoise foot" appearance is seen. At this stage, too, the muscles may show signs of pressure atrophy, and some bone distortion may be observed. When the feet are affected by these verrucosities the condition known as "mossy foot" is produced.

As the disease progresses, the intervals between the attacks of lymphangitis are prolonged until they cease altogether.

The blood supply to the parts affected by elephantiasis is very great, and the veins especially become enormously enlarged.

Elephantoid tissue does not pit readily, and firm prolonged pressure is required to cause an indentation. It has been pointed out by Gregg and Bertwistle that this observation has a practical application in the use of the tourniquet applied over elephantoid tissue before operation. When first applied, the tourniquet may be efficient, and later on indentation occurs, sufficient to permit arterial flow, but tight enough to prevent venous return and so cause profuse hæmorrhage.

TREATMENT

General measures. The subject of treatment of elephantiasis is a prolonged affair and cannot be readily dismissed. These measures may be discussed under the following headings:

(1) *Focal sepsis.* In the successful treatment of elephantiasis, especially as a preventative measure, attention must be directed to any source

of focal sepsis. The septic foci may be, and often are, septic teeth, whilst Sistrunk reports that in two of his cases the tonsils were grossly infected. Though teeth and tonsils probably form the chief source of infection in non-tropical elephantiasis (*elephantiasis nostras*), chronic appendicitis and pelvic or urinary infection may also be held responsible.

(2) *Vaccines and protein shock.* As it has been pointed out by numerous workers on this subject, the author by his work in Fiji, by F. G. Rose in British Guiana, and especially by the Filariasis Commission to British Guiana in 1924, septic infections are a very frequent accompaniment of filarial diseases, as they also are in *elephantiasis nostras*, and prophylactic injection with mixed streptococcal and staphylococcal vaccine is advisable, especially preparatory to operation. A polyvalent vaccine (killed cultures) composed of ten million streptococci with ten million staphylococci (*S. pyogenes aureus*) given at weekly intervals is a rational method. In British Guiana these therapeutics have been utilised, apparently with some success, as a method of preventing or warding off further attacks of lymphangitis or elephantoid fever.

Protein shock therapy, given on empirical grounds, using intravenous injections of killed typhoid-paratyphoid cultures (T.A.B. vaccine) in doses of fifty and a hundred million organisms, which causes a considerable systemic reaction, has been found to exert some influence upon early elephantoid conditions, and to cause a temporary reduction of the swelling. This method is always worth trying in the pre-operative treatment of the disease. If the patient is in an enfeebled physical condition, this method is contra-indicated.

(3) *General health.* It is most important that the general health should be attended to, and any other concomitant infections should be dealt with. In native races these are commonly malaria and almost universally an ankylostome infection. This helminth, as well as other worms such as ascaris, should be removed by the combined carbon tetrachloride and oil of chenopodium treatment.

(4) *Local measures.* In the earlier stages of elephantiasis of the leg, the patient should be encouraged to persist with bandaging with elastic bandages, massage, and elevating the limb whenever possible, and later some control may be obtained by tight elastic bandaging or by stockings which should be made to fit accurately and should be constructed of some porous or easily washed substance, such as stockinette. A perfectly fitting stocking should embrace the dorsum of the foot, should accurately fit the leg, and reach above the knee. Usually, difficulty is experienced with the upper margin, which extends to the thigh and is apt to constrict at this point. To obviate the pressure of tight-fitting

stockings, and to accommodate the fluctuations in the size of the limb, the stockings may be made to lace up at the sides (fig. 2289).

Finally, it is essential that the affected limb should be elevated and supported by *crêpe* bandages, and massage applied daily. The latter should be both deep and vigorous.

THE OPERATIVE TREATMENT OF ELEPHANTIASIS

Sampson Handley in 1908 first realised the importance of re-establishing the lymph flow, and this he attempted to do by the subcutaneous insertion of silk threads. Later, Lexer modified this method by substituting strips of fascia for the silk threads, but the results were generally unfavourable. Walther further modified the method by burying a rubber tube between the deep fascia and the layer of muscle. The lower end of the tube was left protruding through the deep fascia into œdematous tissue and the upper end was similarly placed in normal tissue. Next Lanz tried to increase the poor anastomosis between the deep and superficial lymphatic systems of the lower limb by inserting a strip of subcutaneous tissue between the intermuscular septum and suturing it into holes drilled into the bone.

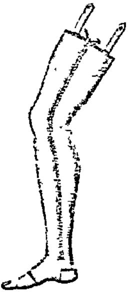


Fig. 2289.—Laced form of elastic stocking, with suspenders, adjustable so as to avoid pinching. (*Hospital and General Contracts Co.*)

Kondoléon's operation, which has been much practised, aims at removing strips of œdematous skin, subcutaneous tissue and deep fascia, two inches wide, medially and laterally from the entire leg. This method has frequently given good results. The success of this operation may be ascribed to the removal of the deep fascia which has been shown by Woollard and Gray to form a barrier to lymphatic anastomosis, and also to their showing that blocked lymphatic capillaries, whilst incapable of forming functioning anastomosis with normal lymphatic capillaries, whose drainage is normal, *can* form such an anastomosis with normal lymphatic capillaries when both have been incised by surgical means. The anastomotic union apparently only occurs amongst the minute lymphatic capillaries.

Since Kondoléon first devised the operation, modifications have been made, especially by Sistrunk who carries it out in two stages.

One side of the extremity is operated upon throughout its entire length at the first stage, and two to three weeks later, the other side is dealt with. At the first operation an elliptical incision narrowing at the

knee is made from the iliac crest to the ankle on the lateral surface, and at the second operation from the groin to the ankle on the medial surface, a sufficiently large portion of skin being removed to reduce the size of the limb to normal.

The margins of the skin are then dissected back for a distance of 6 cms. or more on each side, and the œdematous tissue incised downwards through the deep fascia. The skin, œdematous tissue and deep fascia down to the muscle are removed in one piece.

This allows a broad communication between the superficial tissue and underlying muscles. The skin is closed without drainage and close

Fig 2290.—Case of elephantiasis of lower limbs.
(*"Brit. Journ. Surg." Photograph by Dr A. L. Gregg.*)

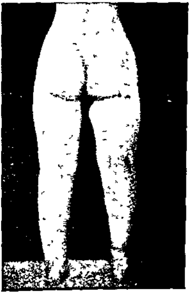


Fig 2291.—Same patient as shown in *Fig* 2290 after operation by Kondoléon's method.
(*"Brit. Journ. Surg." Photograph by Dr. A. L. Gregg.*)

fitting bandages are applied. Immediately following operation, normal saline solution is given per rectum and also subcutaneously.

Sistrunk's post-operative treatment consists in wearing an elastic stocking or bandage for an indefinite period.

Ghormley and Overton have reported on 55 patients operated upon since 1923, of which 50 per cent showed considerable improvement and 11 per cent complete relief. All cases reported on were of the non-filarial form of elephantiasis.

A. L. Gregg reported a successful treatment of an extreme case of elephantiasis of both legs (figs. 2290 and 2291) by successive operations in seven stages, in which practically all the elephantoid tissue on

rind of skin which is thickest towards the lowest and most dependent part, and beneath it a mass of blubbery œdematous tissue in which testes, cords and penis are embedded. The tumour is therefore more or less pyriform in shape (fig. 2293).

Great care must be taken in identifying and separating out the testes and cords. The arteries which supply these enormous growths are of considerable size, and the veins are also very large and bleed freely.

It is necessary that care should be taken in the pre-operative stage, and that the patient should keep to his bed for a week beforehand.

The patient should be placed in the lithotomy position on a horizontal table. The scrotum should be drawn down as far as possible and elastic webbing applied over the mass to expel the blood.

A vertical incision is made commencing in the middle of the symphysis pubis and extending as far as the aperture leading to the penis. The penis is expressed and the penal artery ligatured. A sound is passed to prevent subsequent injury to the urethra. The vertical incision is continued round the scrotum right round to the perineum, and the scrotum divided into two halves.

The testes and cords are now separated from the blubbery mass, the hypertrophied gubernacula being divided, surrounded with gauze and placed on one side. At the base of each half of the scrotum clamps are fixed, care being taken that they are well on to the proximal side of all diseased tissue.

Each half of the scrotum is then cut away distal to the clamps and through healthy tissue. All visible blood-vessels should be secured and tied and the clamps gradually loosened. The skin of the upper and inner aspects of the thigh is undermined and brought together over the testes.

Thiersch skin grafts may be applied to the penis and good cosmetic results are obtained.

The writer is indebted to his colleagues Dr. A. L. Gregg and Mr. A. H. McIndoe, for their kind assistance in the preparation of this article.

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BARTWIS [illegible] L. *Brit. Journ. Surg.*, 1928, XVI, 1, 62, 267.

knee is made from the iliac crest to the ankle on the lateral surface, and at the second operation from the groin to the ankle on the medial surface, a sufficiently large portion of skin being removed to reduce the size of the limb to normal.

The margins of the skin are then dissected back for a distance of 6 cms. or more on each side, and the œdematous tissue incised downwards through the deep fascia. The skin, œdematous tissue and deep fascia down to the muscle are removed in one piece.

This allows a broad communication between the superficial tissue and underlying muscles. The skin is closed without drainage and close

Fig. 2290.—Case of elephantiasis of lower limbs
("Brit Journ. Surg." Photograph by Dr. A. L. Gregg.)

Fig 2291.—Same patient as shown in Fig 2290 after operation by Kondoléon's method.
("Brit Journ Surg" Photograph by Dr. A. L. Gregg.)

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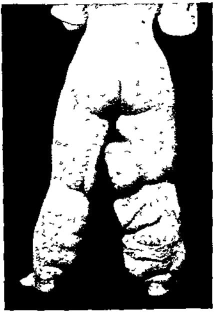

Fig. 2290.—CASE OF ELEPHANTIASIS OF LOWER LIMBS
("*Brit. Journ. Surg.*" *Photograph by Dr. A. L. Gregg.*)

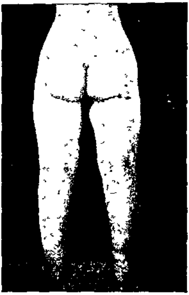

Fig. 2291.—SAME PATIENT AS SHOWN IN *Fig.* 2290 AFTER OPERATION BY KONDOLÉON'S METHOD.
("*Brit. Journ. Surg.*" *Photograph by Dr. A. L. Gregg.*)

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A. L. Gregg reported a successful treatment of an extreme case of elephantiasis of both legs (figs. 2290 and 2291) by successive operations in seven stages, in which practically all the elephantoid tissue on

both legs and labia was removed. The operation consisted of removal from below upwards of as much elephantoid tissue as possible by means of elliptical incisions and undermining, thus removing large masses of blubbery tissue, including underlying portions of deep fascia. The incisions were so planned that the skin edges could best be brought together.

Auchincloss' operation is a modification of Kondoléon's technique and is intended to remove these tender "focal spots" in which the calcified filaria worms are situated in filarial elephantiasis. It consists of two incisions marking out a vertical strip of skin. From its ends V-shaped incisions are made, diverging upwards at the upper end and downwards at the lower. A great amount of skin is undermined with considerable care at a level deep to the corium (fig. 2292).

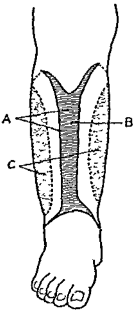

Fig 2292.—Scheme for Auchincloss' operation for elephantiasis.

A. Incisions. B Skin excised. C Shows extent of subcutaneous tissue and deep fascial excision posteriorly This excision is planned to remove maximum number of calcified areas and "focal spots."

(*Reproduced from the "Porto Rico Journal of Public Health and Tropical Medicine."*)

Selection of cases. The selection of cases for operative treatment is regarded as a most important factor. Recent attacks of cellulitis should not constitute a contra-indication. The severe cases give the best results and the improvement in the milder cases tends to be disappointing.

Gillies' and Fraser's Operation. This is a plastic operation which has recently been introduced and is still on trial. The operation has been reported upon at length by A. H. McIndoe. The operative technique has been planned upon the expectation that the existing lymphatics of the lower limb will anastomose with another set from the arm, if the two are brought together in surgical juxtaposition. This procedure rests upon the experimental work of Woollard and Gray who have shown that such an anastomosis of lymphatic capillaries with normal lymph vessels will take place if brought into contact by surgical means, but will not do so if a fibrous barrier intervenes. The lymphatics of the forearm are brought by means of a "flap" close to the upper and outer aspects of the thigh, with the idea of transporting the stagnated lymph via the arm lymphatics into the general lymphatic system via the thoracic lymphatics, and with the idea of forming a bridge across the impermeable lymphatic barrier in the pelvis.

The operation has been carried out so far in four stages. Incisions seven inches long are made on the flexor aspect of the forearm corresponding to the area on the elephantoid leg. Cross incisions are made at the extremities to enable two small flaps to be turned outwards and inwards respectively, passing through the deep fascia.

A similar area is laid bare on the corresponding thigh. By bringing these flaps into contact the deep fascia of the thigh is approximated to the deep fascia of the forearm, and the flaps are sutured on each side like wings, and are left in position with the arm bound to the side for three weeks or more till the union is complete. Further operations are undertaken to undermine the remaining portions of the flaps which now extend from the centre of the thigh to the axilla.

In the final operation the flaps are severed, and interchange of arm, body and leg skin completed. Only a limited number of cases have so far been subjected to this operation, but it may be stated that it promises well for the future.

OPERATION FOR ELEPHANTIASIS OF THE SCROTUM

This is an eminently satisfactory operation and aims at the removal of a redundant mass of tissue, so that considerations of subsequent lymph drainage do not apply.

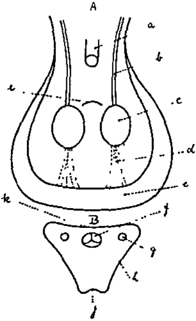

Fig 2293.—Diagram of anatomy of elephantiasis of scrotum

A. Diagram of scrotum.
- (*a*) Penis
- (*b*) Spermatic cords
- (*c*) Testes
- (*d*) Gubernacula testis
- (*e*) Hypertrophied skin.
- (*l*) Channel leading to penis.

B. Transverse section of neck of scrotum.
- (*f*) Penis.
- (*g*) Spermatic cords
- (*h*) Sides
- (*j*) Apex
- (*k*) Base.

The operation is commonly performed for the removal of scrotal tumours such as occur in most filaria-infested countries.

These tumours consist of two portions—the outer or hypertrophied

rind of skin which is thickest towards the lowest and most dependent part, and beneath it a mass of blubbery œdematous tissue in which testes, cords and penis are embedded. The tumour is therefore more or less pyriform in shape (fig. 2293).

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CHAPTER VI

Hodgkin's Lymphogranuloma

by

Sir Humphry Rolleston, Bart.

Synonyms. Hodgkin's disease (Wilks), Lymphadenoma (Wunderlich), Lymphadenoma malignum, Lymphogranulomatosis, Malignant lymphoma. Anæmia lymphatica, Adénie (Trousseau).

Other synonyms are not entirely suitable; thus "pseudo-leukæmia," sometimes erroneously employed for this disease, was introduced by Cohnheim (1865) to describe quite a different pathological state, viz. the changes of leukæmia in the lymphatic glands without the corresponding blood picture. Virchow (1864) used the term lymphosarcoma which unfortunately caused confusion with sarcoma of a different and quite definite microscopical structure. The name probably most generally familiar in this country is lymphadenoma, but it has been used in other countries for enlargement of lymphatic glands quite different from, and of much less serious import than, Hodgkin's lymphogranuloma. Wilks, who in 1865 used the name "Hodgkin's disease," in 1889 drew a distinction between lymphadenoma and Hodgkin's disease. Turnbull has used the title Hodgkin's lymphogranuloma for more than a quarter of a century.

Definition. A progressive, usually chronic, condition with a characteristic hyperplasia of the hæmatopoietic tissues, which may extend to other structures and behave like a malignant growth (Hodgkin's sarcoma). It is probably due to an ultra-microscopic virus. Though it responds temporarily to arsenic and to X-rays and radium, it has sooner or later been uniformly fatal.

Ætiology. It may occur at any age, but is most frequent in the 3rd and 4th decades. Males are attacked twice as often as females. In very rare instances two members of the same family have been affected.

Pathogeny. Various infective agents have been put forward as responsible: (1) A special form of tuberculosis was described by C. Sternberg (1898); Fraenkel and Much (1910) incriminated a granular form of the tubercle bacillus, and Ewing (1929), stating that "tuber-

culosis follows Hodgkin's disease like a shadow," appears to be in sympathy with this view. L'Espérance (1928) maintained that avian tuberculosis was responsible, but this has been vigorously contested (van Rooyen). Inoculation of animals with lymphogranulomatous material has given positive and negative results in different instances, and it is generally agreed that the positive reactions were due to secondary tuberculous infection of an already lymphogranulomatous gland. (2) Spirochætes have been described (White and Proescher, 1908), and dismissed (Gordon). (3) A pleomorphic diphtheroid bacillus theory was put forward by Yates and Bunting (1917), but has not been confirmed. (4) As the result of prolonged investigation, Gordon and his co-workers on "The Rose Research on Lymphadenoma" (1932) at St. Bartholomew's Hospital have brought forward much evidence in favour of extremely minute spherical or oval "elementary bodies" which have been photographed. (5) The disease has been regarded as a granuloma due to an unknown infection. (6) As a lymphoblastoma and allied to leukæmia. (7) As a transition between a granuloma and a new growth.

It seems probable that in addition to cases with a characteristic histological picture there is a gradation of atypical forms of the disease constituting the "Hodgkin group" (Gordon). The inclusive term lymphoblastoma has been employed to cover Hodgkin's lymphogranuloma, mycosis fungoides, leukæmia and lymphosarcoma. The portal of entry of the infection is unknown; but a possible one, the tonsil, is seldom affected.

Morbid Anatomy. The hæmatopoietic tissues, including the bone-marrow, undergo a cellular hyperplasia which is more like that of chronic granuloma than that of sarcoma. It is, however, remarkable that the lymphoid tissue of Peyer's patches and the solitary follicles of the small intestine and colon are so rarely affected. Cases of diffuse invasion of the walls of the gastro-intestinal tract, sometimes suggesting lymphadenoma, are usually histologically of a different nature, such as lymphosarcoma. The lymphatic glands are enlarged and discrete, on section present a greyish, somewhat gelatinous appearance, and may show yellow spots of necrosis but, unless secondarily infected, do not suppurate or, unless tuberculosis has supervened, show gross caseation. The capsules of the glands remain intact and are free from peri-adenitis in the absence of secondary infection, e.g. tuberculosis, or the supervention of Hodgkin's sarcoma. At first soft, the glands gradually become fibrous and hard. Though enlarged superficial lymphatic glands are usually the first indication of the disease and have therefore

been regarded as its starting point, there is a growing opinion that these glands are often outlying extensions of primary intra-thoracic infection, especially when the axillary glands are enlarged, or of primary intra-abdominal disease, particularly when the inguinal glands are the first noticed to be enlarged (Ewing; Symmers; Minot and Isaacs). In the neighbourhood of the enlarged affected glands new masses of lymphoid tissue develop as a compensatory measure, but in their turn become invaded by the morbid process. The spleen is almost always enlarged and usually contains whitish or yellowish areas around the Malpighian bodies (the "hard-bake spleen"); these masses do not show the central softening seen in the somewhat similar tuberculomata (fig. 2294). Masses of this nature are less often present in the liver and kidneys. The lungs occasionally show this infiltration either locally or diffusely. In the late stages the capsule of the lymphatic glands may be penetrated by Hodgkin's sarcoma, which may invade other structures such as muscle. In a small number of cases amyloidosis occurs without any other cause, such as suppuration or syphilis.

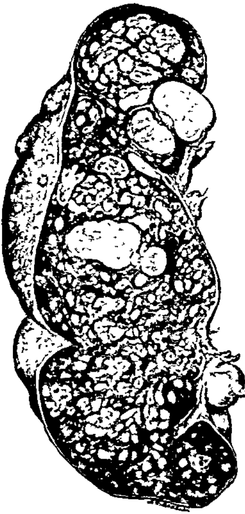

Fig. 2294.—"Hard-bake" spleen.
(*Museum, Middlesex Hospital.*)

The *histological* change in the glands, fully described by F. W. Andrewes, and independently by D. Reed, in 1902, is of practical importance, as on its presence certainty of diagnosis has long depended. In the earliest stage there may be a short-lived increase of the lymphocytes, but the important change is proliferation of the reticular and endothelial cells producing large pale cells with elongated vesicular nuclei, and resembling the epithelioid cells of the tuberculous large-celled hyperplasia of lymphatic glands. Multinuclear giant cells ("lymphadenoma cells"), quite different from those of tuberculosis

and from foreign-body giant cells, are the most characteristic of the varied cellular elements (fig. 2295). Eosinophil and plasma cells are also often, but not constantly, present, the eosinophil cells being probably brought from the bone-marrow, and not produced in the lymphatic glands. As time goes on, the glands show an increasing amount of hyaline fibrous tissue.

Clinical picture. In the vast majority of cases the first evidence of the disease is the painless enlargement of small, discrete, easily movable lymphatic glands, usually in the neck, especially just above the clavicle and in the posterior triangle (see fig. 2296). The glands gradually enlarge

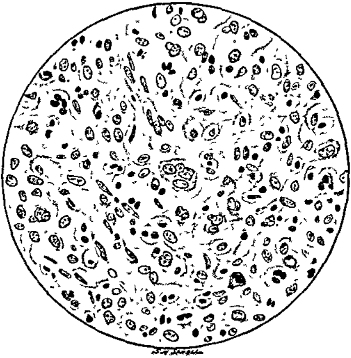

Fig. 2295.—SECTION OF A LYMPHATIC GLAND IN A CASE OF HODGKIN'S DISEASE. A MULTINUCLEAR GIANT CELL IS WELL SHOWN IN THE CENTRE OF THE FIELD.

and their extent spreads so that both sides of the body are affected. In some cases, however, pruritus precedes the appearance of any glandular involvement. The glands are soft at first, but later become hard and may diminish in size from fibrosis. Shrinking of the superficial glands, either spontaneously or after treatment, is not necessarily a good sign, for there may be concomitant extension and enlargement of the deeply-seated glands at the back of the abdomen and in the thorax. Enlargement of the spleen becomes more frequent as the disease progresses. Pressure symptoms from involvement of nerves, veins, the trachea and œsophagus may cause pain and loss of power, œdema, cyanosis, especially of the face, dyspnœa, displacement of the trachea, and dysphagia. Pressure on the spinal cord and the nerve roots may give rise to pain, paraplegia, and possibly herpes zoster.

Fever. Some febrile disturbance, especially of a mild character, is frequent, but the most important and remarkable is the relapsing or recurrent form. This was described by Murchison in 1870, and later by Pel (1885) and Ebstein (1887), hence the eponym Pel-Ebstein fever. It resembles the relapsing fever in some protozoan infections, such as rat-bite fever, but its span from the middle of one pyrexial period to that of the next is longer, from 15 to 25 or even 36 days (Hall and

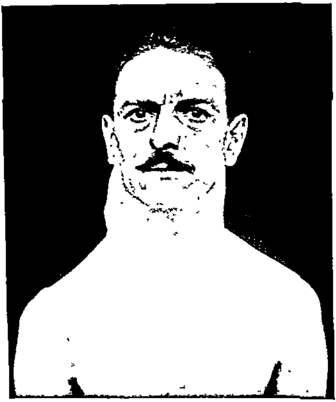

Fig. 2206.—Case of early Hodgkin's disease.
(*By courtesy of Mr. Cecil P. G. Wakeley*)

Douglas). The cause of the fever is not certain; it is not explained by secondary infections; but absorption of protein from necrotic foci in the glands has been suggested (Symmers).

Blood. In the earliest stage the red count may be normal, but later there is a progressive secondary anæmia of a chlorotic type which may become so severe as to necessitate transfusion. The white count does not show any constant or characteristic change. Usually there is not any leucocytosis, and there may be leucopenia with a relative lymphocyte increase. In a late stage when generalisation is rapidly taking place a polymorphonuclear leucocytosis has been described. Exceptionally, especially in the rare acute cases, there is an eosinophilia which may be very considerable, 70 per cent of the white cells even being

eosinophils; it has been thought to be a reaction in response to a foreign protein liberated from necrotic foci in the glands (Weber and Bode) which also causes pruritus and Pel-Ebstein fever. Mast cells may become obvious in the film.

Cutaneous manifestations of various kinds have been noted in about a quarter of the cases (Ziegler). Pigmentation may be due to the administration of arsenic, but may occur in its absence from involvement of the adrenals and of the sympathetic. Scratching due to pruritus may play a minor part in darkening the skin. Pruritus, thought to be toxic in origin, is the commonest cutaneous symptom; besides preceding any other evidence of the disease it may supervene in the late stages; it may be continuous, but is more often paroxysmal, be generalised or more rarely localised, and be accompanied by perspirations or by eosinophilia. The itching and the resultant scratching may be responsible for a prurigo-like papular eruption which consists in a small-celled infiltration around the sweat glands. Lichenification and pyogenic lesions may also be due to the scratching. A much rarer event is a true lymphogranulomatous infiltration of the skin, which must be distinguished from the less rare leukæmic infiltration, from sarcoids and sarcoma of the skin. Generalised exfoliative dermatitis and bullous eruptions have been recorded. Herpes zoster may be due to arsenical treatment.

Different forms of the disease have been described, according to its course—acute, chronic and latent—or according to its prominence in different parts of the body—generalised, thoracic, abdominal, splenic, hepatic, and a retroperitoneal form in which, except sometimes for splenic enlargement, there may not be any palpable tumour. Intrathoracic involvement may behave like a mediastinal tumour and cause dyspnœa, venous stagnation, cyanosis, and pleural effusion which may be chylous or chyliform.

Abdominal symptoms. Enlargement of the spleen is in rare instances an almost isolated sign, so that a splenic form has been described. The spleen is palpable in about 70 per cent of the cases. The liver is frequently and sometimes much enlarged, and an hepatic form has been described (Olmer). Abdominal symptoms, such as pain, heartburn and diarrhœa, may occur quite early in the course of the disease. In some cases the pain may be so severe as to imitate peptic ulcer. Pain in the lower part of the back may be correlated with enlargement of the retroperitoneal glands. Jaundice may be due to pressure on the bile-ducts and may be intermittent, corresponding with the glandular swelling occurring in the bouts of relapsing fever. Ascites may also occur.

Nervous manifestations. Murchison (1869) reported convulsions and delirium. Invasion of the intervertebral foramina by an extension from retroperitoneal glands may cause pain and, from pressure on the spinal cord, paraplegia. In extremely rare cases acute meningo-encephalopathy (Barker) has been described.

Complications. Generalised tuberculosis has been estimated to occur in a quarter of the cases (Ziegler). The relapsing Pel-Ebstein fever, which is not so rare as the recorded cases would suggest, and the transformation into Hodgkin's sarcoma may be regarded as complications.

Prognosis. So far as is known, the disease is invariably fatal, usually after a course of two to three years. Latent cases, in which little change occurs for some time after the detection of enlarged glands, have lasted ten or fifteen years, but, on the other hand, acute cases may terminate in a few weeks to two or three months. Cases showing the relapsing type of fever run a more rapid course than the ordinary cases, and the interval between the onset of this fever and death has been found to be about seven and a half months (Batty Shaw).

Diagnosis. The positive determination of the disease can be made by the demonstration of the characteristic histological changes in a superficial lymphatic gland removed as a routine. There is the fallacy that the gland removed may be one enlarged not by the presence of the disease but by hyperplasia compensatory for the destruction of lymphatic tissue elsewhere. It has been recommended that the glands selected for biopsy should be hard and fibrotic and not recently enlarged (Turnbull).

Gordon's biological test. Intra-cerebral injection of an emulsion of an affected gland into rabbits or guinea-pigs gives rise, after an incubation period of one to several days, to symptoms of encephalitis; this is not produced by similar injections of lymphatic glands with other morbid lesions. This test is chiefly valuable in the diagnosis of disease in an early stage, for glands from chronic cases may give a negative reaction.

Differential diagnosis must be made from forms of tuberculous adenitis and lymphosarcoma by means of a microscopic examination of an excised gland; from lymphoid leukæmia a blood examination should be decisive. Glandular fever might for a time suggest the onset of Hodgkin's disease. Retroperitoneal cases may imitate typhoid fever, which can be eliminated by agglutination tests. The splenic form may imitate chronic splenic anæmia, and the hepatic form when accompanied by fever may simulate hepatic abscess. Other forms of reticulosis should be distinguished by microscopic examination of a gland removed for diagnosis. The condition of splenomegalia lymphatica hypoplastica,

described by Brill, Baehr and Rosenthal (1924), showed remarkable hyperplasia of the lymphatic follicles and was extremely susceptible to irradiation.

Treatment. Arsenic, either by the mouth or by intravenous injection of arseno-benzol preparations, has earned a reputation for producing a remission, but glandular enlargement recurs and then often does not respond to arsenical treatment. X-rays exert a powerful influence in reducing the size of soft glands, and the patients may improve so much as to return to their ordinary life. But hard glands are little changed, and unfortunately glandular hyperplasia, after first subsiding under treatment, recurs and then usually fails to respond to irradiation as before. Cases with relapsing fever do not react to irradiation (MacNalty). Overdosage of X-rays may lead to generalisation and may shorten life (Minot and Isaacs), and doubt has sometimes been expressed if X-rays, though they certainly relieve the symptoms, appreciably prolong life. Radium has been much used and has been thought to be more effective than X-rays, and radon seeds have been employed. The remissions following radium therapy vary from 6 to 18 months.

Treatment by *irradiation* (X-rays or radium) combined with mixed toxins of erysipelas and *bacillus prodigiosus* (Coley's fluid) gave rise to considerable remissions in Coley's hands.

Specific treatment, such as the injection of serum from chickens inoculated with suspensions of the lymphogranulomatous glands, has been tried. A sensitised vaccine of the " elementary bodies " (Gordon) has given very encouraging results in early cases (Warner); but more experience of this treatment is essential.

Surgical treatment should be employed as a palliative measure only, for example, to relieve pain or to remove pressure on the trachea. Extensive dissections, such as were originated for carcinoma of the breast by Halsted and Crile, are likely to be disappointing, as affected glands may escape removal.

Generalisation of the disease may follow operations on the enlarged glands, or even a biopsy, but rapid spread may have begun before, and been responsible for the symptoms leading to operative interference. Some writers, however, such as Minot and Isaacs (1926), consider that early removal supplemented by irradiation is probably of definite benefit.

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CHAPTER VII

Glandular Fever

by

Charles R. Box

Glandular fever (Infectious Mononucleosis) is an acute febrile and infectious adenitis with a characteristic increase in the mononuclear cells of the blood. The course is benign; complications are rare. The disease was first observed in children by Pfeiffer who described it in 1889, under the name of " Drüsenfieber." Apart from an observation by Türck in 1907, and the report of a few cases of alleged lymphatic leukæmia with recovery, it was nearly thirty years before a striking blood picture was noted by Sprunt and Evans and by Longcope in an infectious angina which was not, however, then identified as glandular fever. This identification we owe to Tidy and Morley in 1921.

Glandular fever is thought to be a virus infection, although J. O. W. Bland, as the result of transmission experiments, believes it to be due to a protozoon. There is no convincing evidence that Vincent's organisms can cause the disease as some have surmised. The throat, the respiratory tract, and perhaps the bowel are the portals of entry. The mononucleosis is distinctive, and the assumption that this is due to individual idiosyncrasy is disproved in that the same individual reacts to other infections by a polynuclear leucocytosis.

Glands have often been excised for examination. They are discrete, encapsuled and greyish-white. The cut surface is homogeneous and glistening, with perhaps a few petechial hæmorrhages. Microscopically the normal structure, although distorted, is still discernible. The germ centres are hyperplastic and infiltrated with large, pale, oval or polygonal cells, many of which have lobulated or indented nuclei like the cells found in the blood. This hyperplasia of the reticulo-endothelial system is the outstanding feature.

The disease may occur in localised epidemics; sometimes it is more widespread, but many isolated cases occur, and it is with these that diagnosis may be in doubt.

Infectivity is slight and its duration appears to be very short. The

incubation period is from 5 to 15 days, usually about a week. More males than females are attacked. No age is really exempt, but most attacks occur in school children and young adults. Up to the age of 15 years glandular swelling is the prominent feature, but in adults the infection is apt to show itself as an obscure fever identified after a variable period by the supervention of adenitis. Sometimes faucial inflammation is unusually pronounced, its nature being finally elucidated by detection of the characteristic mononucleosis.

Onset in the younger patients is usually with febrile symptoms of no great intensity, and slight soreness of the throat. The tongue may be furred and the bowels confined. Sometimes invasion is more severe, with shivering, vomiting, headache, or even delirium. Sweating and epistaxis may occur. Prodromal symptoms usually last for a day or two before the glandular swelling appears, but they may be so slight as to escape attention, in which case the adenitis or consequent stiffness of the neck may first call attention to the illness.

In a typical case the adenitis is most pronounced in those glands of the carotid chain which underlie the upper half of the sterno-mastoid muscle. It is often unilateral at first and frequently left-sided. In degree it is quite out of proportion to the trivial faucial inflammation, but sometimes a follicular or even a membranous exudate appears on the tonsils, constituting an anginous variety of the disease. The cervical swelling is rapid and painless, the conglomerate glands forming a visible tumour the size of a pigeon's egg or larger below the angle of the jaw. Accompanying fever ranges from 101° to 103° F. or more. The swelling is elastic and tender, but there is rarely any redness or œdema of the overlying skin. Suppuration is very exceptional.

The cervical adenitis is often a part of a widespread but insignificant enlargement of glands in other parts of the body, such as the posterior triangles of the neck, the axillæ, groins and epitrochlear regions. These glands are discrete, mobile and painless. Occasionally the brunt of the disease falls on the bronchial or mesenteric glands, giving rise to distinctive types known as thoracic and abdominal. In the former, a paroxysmal cough simulates pertussis, and dysphagia may occur; in the latter, abdominal pain may mimic appendicitis. Sometimes the enlarged mesenteric glands can be felt.

Enlargement of the spleen is the rule rather than the exception, the edge being palpable an inch or more below the costal margin. In some cases the liver is enlarged as well.

A sparse and ill-defined eruption may be present on the trunk but is exceptional in this type of the disease; in some cases it suggests

typhus or typhoid fever, in others measles. In fulminant cases cutaneous petechiæ have been observed on the legs and trunk.

The fever after a few days becomes intermittent in type, and usually subsides within a fortnight, but may persist for several weeks. The pulse-rate is not unduly rapid, and it is only in prolonged attacks that signs of cardiac weakness have been observed.

As a rule, the glandular enlargement outlasts the fever, resolution being slow. Rarely, it only appears when the fever has subsided. The disease may in some instances progress by stages, one group of glands becoming enlarged as another subsides.

With the recognition of the diagnostic significance of monocytosis, an adult type of the disease was described in London and its neighbourhood in 1930. This differs in incidence and course from the juvenile type described above. The onset may be sudden or insidious. The outstanding clinical features are:

Adult incidence; prolonged fever of a type suggesting typhoid infection; a scanty maculo-papular eruption on the trunk at the end of the first or beginning of the second week, and a delay of two or even three weeks from the onset before the glandular swellings appear. The glands are not so prominent as in the other type of the disease. The onset of monocytosis is mostly coincident with the glandular swellings, as also may be the detection of splenic enlargement. A peculiarity is the development of a transient Wassermann or Kahn reaction in the blood. Recrudescences or relapses may occur, but recovery is the rule.

The blood picture of glandular fever shows a striking increase in the mononuclear cells. This sets in some days or, in the adult form, even a week or two after the onset. It may only occur when the glandular enlargement has become pronounced. There is no marked anæmia and no platelet reduction. The leucocyte count may reach 40,000, but it is seldom above 20,000 and often only 10,000 per c.mm. Of the total white cells the lymphatic or mononuclear varieties average 40 per cent, but may increase to 90 per cent in some instances. Three varieties of these cells may be recognised in the smears: (1) Small lymphocytes, as in normal blood; (2) large mononuclear cells, also resembling those of normal blood; and (3) aberrant cells, which usually preponderate, larger than the small lymphocyte, with an indented or lobulated nucleus, and a varying complement of azurphil granules. The protoplasm is deeply basophil and may be vacuolated. These atypical cells have been regarded by some as lymphoblasts, but others note their resemblance to plasma cells. The oxydase reaction which

occurs solely in granule-containing cells of the myeloid series is negative. The granular white cells of the smears average 10 to 20 per cent and there may be a shift to the left so that a few myelocytes appear. Eosinophils and mast cells are present.

The duration of the mononucleosis is extremely variable; in some cases it persists for months, in others it is transitory. Unless several counts are made at short intervals it may be missed entirely.

Sufferers from glandular fever develop in their blood serum heterophil anti-bodies against the red corpuscles of sheep. This is the Paul-Bunnell reaction. It becomes positive with the appearance of the swollen glands. A titre of 1 in 100 is diagnostic.

Complications are very few, but convalescence may be tardy. A slight temporary albuminuria with tube-casts may occur, and in some 6 per cent of the cases hæmorrhagic nephritis ensues. Suppurative otitis media and retropharyngeal abscess have been recorded. In exceptional cases, chiefly those with marked faucial infection, the cervical glands suppurate. Broncho-pneumonia and collapse of lung have been seen.

Diagnosis. During an epidemic diagnosis should not be difficult, but isolated cases give rise to doubt because slight sore throat with secondary enlargement of the glands of the neck is a very common event. When the typical blood count is available this is characteristic, stress being laid on the marked increase in the plasma type of cell.

When faucial inflammation is pronounced, other forms of tonsillitis and certain infectious fevers must be excluded. Bacteriological examination is important and will certainly detect diphtheria. The frequent detection of Vincent's organisms in glandular fever has already been commented on. The possibility of a primary syphilitic infection of the lips, tongue or fauces should be remembered. Acute septic tonsillitis of streptococcal origin may give rise to a rapidly swelling adenitis of the tonsillar and other glands of the deep cervical chain, with prostration, high fever and perhaps rigors, but there is generally a polynuclear leucocytosis. Agranulocytic angina is distinguished by the disappearance of all granular elements from the blood.

Differentiation from mumps should be easy, despite the accompanying lymphocytosis. The statement that the salivary glands may swell in glandular fever is an error, although the disease has been described as "aberrant mumps." Lymph glands may overlie the submaxillary and parotid glands and be mistaken for them.

In German measles the cervical, and especially the mastoid and

occipital, glands may be enlarged and tender for some days before the distinctive rash appears, after which, as a rule, they quickly subside. After the eruption a leucopenia may be found, which is maximal on the third day. The number of polymorphonuclear cells is diminished, but the proportion of Türck cells and of plasma cells is said to be higher than in any other infectious disease. Within a week or two the blood becomes normal.

Whooping-cough may be simulated when the bronchial glands are enlarged, and moreover in whooping-cough there is a lymphocytosis with a high percentage of small lymphocytes. Detection of palpable superficial glands is in favour of glandular fever, whilst presence in the sputum of numerous slender Gram-negative bacilli points to whooping-cough.

Fevers of the enteric group may be simulated if pyrexia is prolonged before the adenitis appears. Diagnosis will depend upon the clinical course of the disease, coupled with blood culture in the early stage, bacteriological examination of the urine and fæces, and on the appropriate agglutination reactions. A transient initial leucocytosis followed by leucopenia with a relative lymphocytosis is characteristic of typhoid and paratyphoid fevers. A few cases of glandular fever have shown a misleading agglutination with typhoid " O " antigen in low titres. On occasions abortus fever has been accompanied by rather pronounced glandular enlargement.

Differentiation from acute leukæmia may be difficult. In this disease fever, buccal inflammation, glandular swellings and leucocytosis are evident, but one type of lymphocyte or immature cell forms the bulk of the white cell increase. Progressive anæmia, diminution of blood-platelets, hæmorrhagic tendency and rapid downhill course are important diagnostic points. There is little doubt that cases of recovery from acute leukæmia, from time to time reported, are really examples of glandular fever or infectious mononucleosis. The rare disease, monocytic anæmia, is distinguished by a heavy percentage of large hyaline leucocytes.

The sub-acute type of glandular fever, with recurrent glandular swellings, sweats, and irregular exacerbations of fever may resemble Hodgkin's disease closely, but the blood picture and ultimate course differentiate it. Microscopical examination of an excised gland is valuable in doubtful cases.

Tuberculous adenitis is distinguished by its greater chronicity and by a tendency to peri-adenitis, softening and involvement of the skin. Blood changes are inconstant, but signs of tuberculosis may be found elsewhere.

Stiffness of the neck, caused by tender, swollen glands, may lead to

suspicion of early spinal caries. This is negatived by detection of the tender glands and the absence of radiological evidence of bone disease. The occurrence of the characteristic blood picture and the transient nature of the symptoms will establish the true diagnosis.

The abdominal symptoms of glandular fever have not infrequently led to operation for appendicitis. Detection of enlarged accessible glands, a palpable spleen, and the nature of the blood changes should prevent mistake. At operation lymphatic hyperplasia of the appendix and markedly swollen lymph glands should arouse suspicion as to the nature of the case.

Treatment is symptomatic. Ultra-violet radiation is said to speed up the disappearance of the glandular swellings. In protracted cases injection of the blood serum of a patient convalescing from glandular fever may bring the disease to a termination.

Infectivity apparently ceases before disappearance of the clinical signs of the disease. Isolation for seven days after the subsidence of the fever and glandular swelling has been recommended in acute cases.

CHAPTER VIII

The Significance and Differential Diagnosis of Lymph-Gland Enlargement

by

R. Sleigh Johnson.

Affections of the lymphatic system, by their frequency of incidence and variability in type, afford one of the common meeting-grounds of medicine and surgery.

In a case of glandular enlargement, blood diseases, factors of constitutional type, infections, specific or otherwise, and new formations may all need consideration in their possible relationship, apart from more localised and directly surgical conditions. In a text-book of surgery it may not, therefore, be out of place to review some of the more important features of lymph-gland enlargement in general, with special reference to ætiology and differential diagnosis.

In any such consideration it must be borne in mind that lymphoid tissue is not confined in its distribution to the lymph "glands" (or lymph "nodes" as they are more correctly defined), but is present extensively throughout the body in other organs, notably the spleen, thymus and tonsils, of which structures it constitutes the larger part, as well as being scattered throughout the mucous membrane of the pharynx and lower intestinal tract. Any generalised affection of the lymphatic system involving enlargement of groups of lymph nodes is in accordance commonly reflected in an accompanying proliferation or other histological change in the lymphoid tissue of one or more of these latter structures.

Besides providing in their germinal follicles the main source of supply to the body of lymphocytes, lymph nodes have the further important function of constituting a line of defence against infection arising within the area of their drainage. Commonly directed against bacterial invasion, this resistance may in other cases be concerned with a variety of foreign substances, or with malignant or abnormal tissue cells, the aim in each instance being the prevention of a general blood-stream involvement. In this process, whatever its specific pathology, the affected nodes become enlarged and clinically apparent. With

regard to clinical examination, it may be said that, unless there is generalised wasting, a palpable lymph node is a pathological one, though perhaps only from repeated minor sub-infection, the anatomical situation of the various groups of nodes being such that they normally lie hidden and impalpable in protective fat or connective tissue.

The *differential diagnosis* in a given case of lymph-node enlargement will follow from a consideration of the undermentioned main aspects of the case:

(1) The distribution of the enlargement, i.e. which group or groups of nodes are affected.
(2) Possible abnormality in the area or areas of lymphatic drainage.
(3) The physical characters of individual enlarged nodes.
(4) *Affection of other lymphoid structures.*
(5) Evidence of general systemic disturbance, and if present its nature.

Each of these aspects may be further considered. Of primary importance is the determination as to whether the involvement of glands is a local process or whether the enlargement is a generalised one. Accordingly, in any case of glandular enlargement, even where apparently localised to a single gland or group of glands, a brief general survey of the common main lymphatic zones should be made; if carried out as a routine, palpation in turn of the cervical, axillary and inguinal regions will help to avoid the error of confusing local with general systemic disease, and takes but little time; moreover, in multiple enlargement one such zone frequently dominates the picture. If only local enlargement is detected, the possibility of a general systemic condition is made less likely but not excluded, and special pathological investigation may in some cases still be required. No detailed note is called for here regarding the detection by inspection and palpation of enlarged glands in the common superficial areas, except perhaps to stress the need for the fullest relaxation by suitable posture of the limb concerned, and to comment on the masking of enlarged glands which sometimes ensues in inflammatory cases from associated muscular rigidity and reflex spasm. Reference may also be made to the possible detection by deep palpation of enlarged glands within the abdomen, whether lying in the mesentery, usually having some range of mobility, or situated more fixedly in the deep iliac or aortic areas. As with other abdominal swellings, preliminary purgation may be required in doubtful cases, and, if the circumstances warrant, a confirmatory examination under anæsthesia. In some special cases the presence of enlarged glands may in impalpable

areas be suspected or inferred from accompanying pressure effects peculiar to their position, e.g. jaundice and ascites from enlarged glands in the portal fissure. The value of X-ray investigation of the abdomen, as for suspected tabes mesenterica, is limited, seeing that only those glands will be revealed in which the tuberculous lesion has healed by calcification, while more active disease shows no comparable opacity and is likely to give negative or inconclusive results.

A further region where enlargement of important groups of glands is similarly obscured is within the thorax, and in any suspected condition in which generalised glandular enlargement is known to occur this site also should be investigated. A number of intricate physical signs are described from which enlargement of the tracheo-bronchial glands is to be deduced, but it may be affirmed that these are of no clinical value unless the swelling of glands be of a gross order. Even so, such signs as are produced result commonly not from the mass of glands *per se*, but from their pressure effects upon adjacent lung tissue, producing pulmonary collapse, or upon lymphatic vessels and veins in the posterior mediastinum or lung roots with ensuing pleural effusion, distension of surface veins, and perhaps œdema of the chest wall, upper limb or face. With such enlargement of this group of glands, impairment or dullness may be found in the inter-scapular region or at the lung base, with weak or altered breath sounds. This cause of unexplained pleural effusion or obscure swelling (from œdema) of one breast is therefore to be kept in mind. Gross enlargement of glands in the anterior or superior mediastinum may similarly be shown by dullness anteriorly, perhaps with a visible swelling and evidence of pressure upon the air-passages or veins and nerves of the head and neck.

In some cases the effects described are due not directly to enlargement of the glands themselves, but to involvement of adjacent organs, such as the lung, in an infiltrative spread of the same disease-process; examples are found in carcinoma and, rarely, in Hodgkin's disease. Again, the degree and nature of pressure effects will vary with the underlying pathology, being proportionately greater with a neoplastic than with an inflammatory cause.

Confirmation of gross clinical enlargement, and diagnosis of lesser degrees of enlargement, are in all cases dependent upon X-ray examination of the thorax. Oblique and lateral films will be required in addition to antero-posterior, and heavy exposure may be needed, using a Potter-Bucky diaphragm. Opportunity for investigation should not be deferred until the X-ray picture may have become obscured by secondary pulmonary or intra-pleural events.

A preliminary examination on the lines given will have decided into which category the glandular enlargement falls, whether *local* or *generalised*. If the former, scrutiny is then directed towards the area known to be drained by the group affected, for evidence of primary disease. If present, this is likely to be inflammatory or neoplastic; if inflammatory, it may be acute or chronic; if neoplastic, it is commonly malignant, although pyogenic infection of an innocent and perhaps ulcerated primary growth may give rise to a misleading inflammatory enlargement of the corresponding group of glands.

In *acute inflammatory lymphadenitis* the primary lesion is usually clear: the glands are tender, soft, discrete at first, later perhaps becoming fixed, ill-defined, and confluent from surrounding peri-adenitis and œdema or suppuration with local redness and softening of the skin. One or more glands only of the group may be involved, and that to a differing degree. Lymphangitis proximal to the glands may also be present, with evidence of general intoxication and a leucocytosis.

Chronic pyogenic infection is the commonest cause of localised glandular enlargement, especially of the cervical group, because of the wide prevalence of minor chronic infections of the mouth, ear, nose and throat, or scalp. As contrasted with acute inflammation, there is less tenderness on palpation, while the degree of enlargement is seldom as marked and the glands tend to remain discrete.

Next to pyogenic infection, the most frequent cause of a localised chronic inflammatory lymphadenitis is *tuberculosis*, and again the neck is the usual site, predominantly the anterior triangles. At first discrete, mobile, firm and painless, without tenderness on pressure, with extension of disease through the gland capsule adhesion of glands occurs, both one to another and to adjacent tissues, forming an irregular confluent swelling with less range of movement. Central caseation and liquefaction tend to produce softened fluctuating areas with eventual adhesion to the skin, the thinning and breaking down of which leads to sinus formation and external scarring. A history of contact with a tuberculous patient, and the finding of a positive Mantoux reaction will assist diagnosis at an earlier stage.

Local enlargement of glands secondary to *malignant disease* occurs most frequently from infiltration with carcinoma. Such glands are in themselves completely painless and insensitive to pressure, stony hard in consistency, with early fixation to surrounding structures, and usually appear in the anatomical zone drained by the primary growth. Similarly, secondary sarcomatous glands may form large coalescent masses with like features, although usually of softer texture. Of primary neoplasms arising in lymphatic glands the most important type, namely, lymphosarcoma, shows early tendency to generalisation, and will therefore be discussed with the group of multiple gland enlargement. The same consideration applies to the less common types of chronic inflammatory adenitis, such as Hodgkin's disease and syphilis.

The need has already been stressed in the differential diagnosis of localised lymph-gland swelling for a search for the primary focus of disease, whether inflammatory or a new growth. This latter is not, however, always to be found, and for two reasons. In the first place, infection may have been through a minute

point of entry, the surface abrasion healing while the disease becomes manifest within the glands. Alternatively, and especially with neoplasm, the initial lesion may be situated in some obscure internal part of the body not obvious on surface examination, e.g. the œsophagus, prostate or some deep-seated abdominal organ. Lack of discovery of a primary focus on first examination does not accordingly exclude its presence.

Where swelling of lymph glands is found on examination to involve more than one lymphatic region, investigation is extended to the known causes of *generalised enlargement*. Here a detailed study of the history of illness and a full physical examination of the patient are required. The possible causes may be considered under the headings *acute* and *chronic*, although the division is an arbitrary one.

Concomitant evidence of *acute infection* may be found in general malaise, fever of recent onset, and perhaps a rash, while differential diagnosis is helped by the age of the patient, the situation and character of the enlarged glands, and by special pathological tests.

An acute febrile illness in a child or young adult, having as its main clinical feature a painful enlargement of cervical glands, is likely to be due to *glandular fever* (see also page 4227). In its usual form, this is ushered in by a short prodromal period with fever of 102°–103°F., when enlargement of glands becomes evident in characteristic situations, the commonest being the deep posterior cervical group behind the middle and lower half of the sterno-mastoid, at first confined to one or other side. The enlarged glands remain discrete and mobile, are firm and elastic in consistency, and tender sometimes to the extent of producing torticollis or head-retraction from reflex spasm. With full development of infection, the glandular enlargement spreads in most cases to the axillary groups, and less often to the inguinal and epitrochlear glands. Frequently the mediastinal glands also may be involved, causing an unproductive irritable cough, and the mesenteric with abdominal pain and tenderness, while a slight degree of splenic enlargement is found in over half the cases. The glandular swelling may subside, together with the accompanying fever, within a few days, but not uncommonly both persist for several weeks or rarely months, while general debility and slight tender enlargement of glands may remain for a like period. Breaking down of glands is never seen in glandular fever, but relapse is apt to occur. Less often, soreness of the throat is a prominent feature of the infection. Typically, no rash is present, a point of diagnosis from rubella, but rarely a prodromal maculo-papular eruption has been described before the stage of glandular enlargement.

The diagnosis of glandular fever is clinched by the characteristic blood changes, and a full blood count should be made in any suspected case. Anæmia is not a feature; the total leucocyte count is usually raised to a moderate degree, not often above 20,000, but the striking and pathognomonic feature is the high preponderance in the differential count of mononuclear cells. These may reach a proportion of from 60 to 80 per cent of the total count, and are made up of a variety of types, normal lymphocytes, primitive lymphocytes, monocytes, endothelial and plasma cells. Where opportunity has arisen, examination of excised glands has shown a similar histological change, with hyperplasia of the lymphoid tissue and reticulo-endothelial elements. The characteristic blood changes described have led to the alternative naming of glandular fever as "acute infective mononucleosis." Infectivity is mild but definite, with incubation period of about a week.

Epidemic outbreaks are not uncommon and, as such, afford a point in favour of the diagnosis. The chief difficulties in diagnosis are from rubella and from acute lymphatic leukæmia. The former, as noted below, has a characteristic rash. In the latter condition illness is usually much more marked, and dominates the picture, while the total leucocyte count is greater, with progressive anæmia. A diagnostic fallacy must be mentioned with regard to glandular fever, in that in about half the cases the Wassermann reaction becomes temporarily positive. A specific agglutination test for glandular fever is now, however, available, giving positive reactions up to a dilution in some cases of 1 in 4000 of the patient's serum at the end of the third week of illness.

A further acute condition with glandular enlargement which may simulate glandular fever is *rubella*. Also occurring in the early decades, it is shown by slight or moderate febrile disturbance, with enlargement of the sub-occipital, mastoid and posterior cervical glands on each side. These are firm, discrete and tender, evident by palpation only, and seldom if ever reaching the degree of swelling found in glandular fever. The axillary and inguinal groups are sometimes enlarged, and rarely the spleen is palpable. Mild catarrhal symptoms are present, and the diagnosis is made clear by a characteristic skin eruption, beginning as rose-pink macules on the face and behind the ears and rapidly spreading over the trunk to coalesce into a widespread erythema. Both rash and adenitis are of short duration, a matter of days only. A leucopenia is the rule in the blood.

A painless discrete enlargement of glands in the posterior triangles of the neck, of rubbery consistency, moderate degree and symmetrical distribution, suggests the possibility of *secondary syphilis*. Malaise and a mild degree of fever are commonly present. Suspicion would be confirmed by the finding of mucous patches in the mouth or throat, condylomata, characteristic maculo-papular rash, or primary chancre, and the diagnosis established by a positive Wassermann or Kahn reaction in the blood. Enlargement of the epitrochlear glands also is often present, occasionally accompanied by slight enlargement of the axillary and inguinal glands and of the spleen. This glandular enlargement of the septicæmic stage of syphilis tends to outlive the majority of other secondary manifestations of the disease.

The clinical combination of glandular enlargement with acute febrile illness and a high and progressive degree of anæmia raises the suspicion of an *acute leukæmia*. In this condition the patient, usually under the age of twenty, shows a generalised enlargement of glands, often not great, with striking or extreme pallor, a high degree of fever, often 103°–104° F., and almost invariably an acute ulcerative or phagedænic condition of the mouth and throat. Purpuric hæmorrhages with widespread bleeding from mucous surfaces add to the picture. Slight or moderate enlargement of the spleen is usually found, although in some cases the swelling of both spleen and glands may be minimal. The course of the illness is invariably downhill to a fatal termination within a few weeks. The symptoms described should lead to examination of the blood, by which means the diagnosis is established. A marked secondary anæmia is found, often with liberation of nucleated red cells;

the total leucocytes are commonly increased to a moderate degree, as from 20,000 to 40,000, although the very high white counts of chronic leukæmias are rare. Exceptionally a leucopenia is found. The white cell showing excessive proliferation and responsible for the leukæmic state is most often a myeloblast, although formerly, through an inadequate investigation of staining reactions, these cases were all thought to be examples of acute lymphatic leukæmia. Staining for oxidase granules enables the myeloblast to be distinguished from the large lymphocyte which it otherwise resembles. A true acute lymphatic leukæmia of small lymphocyte type does also occur. There is little or no clinical distinction between the various types. In considering differential diagnosis, the enlarged glands, fever, and palpable spleen, or sometimes liver, may in the initial stages suggest glandular fever. As already noted, however, in acute leukæmia the degree of general disturbance is far more severe, and often such as to render the lymphatic enlargement inconspicuous by comparison. The texture of the glands is moreover softer than in glandular fever. In addition, the pleomorphic nature of the leucocytic response in glandular fever contrasts with the increase in a single type of cell in a given case of acute leukæmia.

A further condition of acute illness with glandular enlargement in children, sometimes causing confusion with glandular fever, has recently been described by H. C. Cameron and by R. M. Miller under the term "*epidemic streptococcal adenitis.*" Abrupt fever follows a mild transitory sore throat, with much prostration and rapid painful enlargement of the tonsillar, cervical, and even occipital glands. These may become greatly enlarged, hard, discrete and tender, with muscular rigidity, rigors and sweats and a tendency for one or more glands to break down and suppurate. From such discharging glands a pure culture of hæmolytic streptococcus has been obtained. Other distinguishing features from glandular fever are a polymorphonuclear leucocytosis rather than an increase of lymphocytes, negative agglutination reactions, and an absence of involvement of the spleen or other groups of glands.

Chronic generalised glandular enlargement. Where a long-standing or insidious enlargement of multiple groups of glands is found, the differential diagnosis lies in the main between *chronic granulomatous forms of adenitis*, *primary blood diseases*, and *new growths*.

Of the *chronic inflammatory affections* the most important, and often the most difficult of precise diagnosis, is *lymphadenoma or Hodgkin's disease* (see also page 4218).

Formerly the subject of much difference of opinion as to whether it was to be regarded as inflammatory or neoplastic in nature, it is now considered by most to be a specific granuloma, a view supported by the coexistence of fever, sometimes of periodic type, the occurrence of natural remissions, the blood picture and the histological features of the glands and other affected tissues. The disease is met with most often, but not invariably, in adolescence and early adult life, and predominantly in the male sex. *An insidious and painless enlargement of glands*, usually on one side of the neck, commonly brings the patient under observation, disturbance of the general health at this stage being slight or even absent. There are, even at this phase, specific clinical features of the glandular enlargement which are of help in suggesting its likely nature. The glands of a group become markedly enlarged, often all in the group to an approximately equal degree, and although forming an obvious swelling, yet the individual glands remain quite discrete from one another and preserve their free mobility, becoming adherent neither to the skin nor to deeper structures. They are initially soft, becoming firm and rubbery, or finally hard from increasing fibrosis with the progress of the disease or as a result of treatment; they are not at any stage painful or tender. Although starting in one area, the tendency to a progressive and orderly spread of glandular involvement to other zones is great, it being the rule rather than the exception when a case is first seen to find evidence of enlargement in most or all of the common superficial areas. With this spread there is accompanying degeneration of general health, wasting, secondary anæmia, pigmentation, pruritus, and fever, sometimes of a periodic relapsing or Pel-Ebstein type of diagnostic significance. A firm moderate enlargement of the spleen is present, and often evidence of simultaneous affection of mediastinal and abdominal glands. Signs of visceral infiltration, as of the lung or liver, may in some cases also be found.

It has been noted that the common path of entry of the infection is via the cervical glands, where the most marked enlargement is therefore often found. Sometimes the initial site of enlargement, however, is one or other axilla or groin. Rarely, a patient may first come under observation with signs and symptoms of deep glandular involvement in the chest or abdomen, and in these cases great difficulty arises in differential diagnosis from lymphosarcoma and other similar tumours, owing to the absence of a removable gland for section. Fever and constitutional disturbances are found, but their cause may not be evident until X-ray examination reveals the deep-seated glands. In other cases, evidence of pressure on the air-passages or nerve trunks may accompany the general symptoms, or if the disease be apparently primary in the abdomen colicky pains and vomiting may call attention to the local enlargement. Jaundice and ascites may sometimes occur. If the likely diagnosis is not suggested by the general features of illness at this stage, involvement of peripheral groups of glands will eventually aid in revealing the condition.

The striking and helpful feature of lymphadenoma in diagnosis is its eventual tendency to widespread involvement of lymphatic structures, as also of other organs. Many such may show a granulomatous infiltration; the skin may be affected, producing palpable nodules; the spinal cord may be compressed from erosion of bony vertebræ; and the kidneys, stomach and intestines be infiltrated apart from the more usual involvement of liver and spleen.

Differential diagnosis is frequently difficult. The likely conditions from which

it must be distinguished are the chronic leukæmias, lymphatic or myelocytic, including their occasional aleukæmic phases, lymphosarcoma, and chronic tuberculous adenitis. Most help is obtained from blood examination and from study of the histology of a suitable gland removed under local anæsthesia.

There is no characteristic blood picture in Hodgkin's disease. The usual findings are a variable, perhaps marked, degree of secondary anæmia with a moderate polymorphonuclear leucocytosis. An absolute eosinophilia is sometimes present, the more so if the case be acute, but is on the whole so inconstant as to be of no value in diagnosis.

Greater help is obtained from biopsy, which may indeed afford the only decisive means of differential diagnosis from lymphosarcoma or tuberculosis, especially in those cases where a single large mass of glands predominates. Even so, it is important to choose for removal one of the less indurated glands of the group, as a densely hard gland is likely to show only the final stage of fibrosis from retrogressive changes and not the typical histological appearances of the active disease.

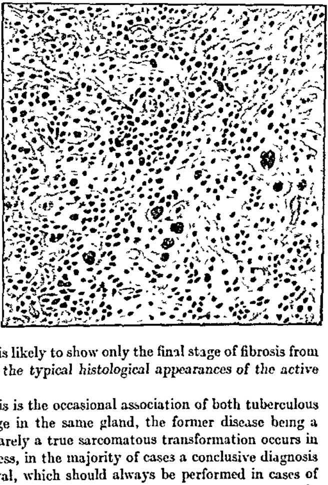

Fig 2297.—Histological appearance of lymphatic gland in lymphadenoma.
(*Dr. L. T. Bond's case.*)

Another fallacy in diagnosis is the occasional association of both tuberculous and lymphadenomatous change in the same gland, the former disease being a secondary infection. Again, rarely a true sarcomatous transformation occurs in Hodgkin's disease. Nevertheless, in the majority of cases a conclusive diagnosis may be made by gland removal, which should always be performed in cases of doubt. The changes found vary in detail, but typically embody the following main features: the normal lymphoid structure of the gland undergoes atrophy of varying degree and is replaced by numerous large, irregularly shaped, pale-staining reticulum cells with single rounded or oval nuclei; scattered among these reticulum cells (or "endothelial" cells) are less numerous and larger multinucleated cells, of characteristic form, having perhaps three to six nuclei which overlap one another within the cell or are arranged in a horseshoe-shaped pattern. Through-

out the gland structure is a diffuse overgrowth of the fibrous stroma, and scattered among the remaining cells are numerous cells filled with coarse eosinophil granules (fig. 2297).

M. H. Gordon in searching for a causative virus of lymphadenoma has shown that the intra-cerebral and intravenous injection into a rabbit or guinea-pig of a broth-suspension of macerated lymphadenomatous gland-tissue, after preliminary filtration, produces in the animal a specific meningo-encephalitis, whilst extracts of glands with other pathological lesions such as lymphosarcoma or leukæmia fail to do so. This would appear to provide then a further and more delicate test for the disease.

Occasionally difficulty in diagnosis from lymphadenoma arises with the uncommon form of *generalised tuberculous adenitis* met with more often in the older patient, with slight or moderate enlargement of the glands in the neck, axillæ and groins, little tendency to caseation or disturbance of health, and greater proliferation of endothelial cells than is usual in tuberculous lesions. The diagnosis is made by removal of a gland and staining for tubercle bacilli, which are usually to be demonstrated.

Lymphosarcoma, being a rapidly fatal disease, is fortunately one of the least common of glandular affections. It may, from its nature, arise in any region of the body containing lymphatic tissue, either within a group of lymphatic glands themselves or in an organ composed of, or normally containing, lymphoid deposits. When originating in a peripheral group of glands. there is a tendency for the growth to form one or more large irregular masses, with early and dense fixation to skin and deep structures. The glands are insensitive and less firm in consistency than are those of lymphadenoma. There is also greater variability in the size of individual glands of a group, as well as in the comparable degree of enlargement of different groups of glands. The severity of illness is, moreover, greater, and anæmia more rapid. Apart from direct infiltration of adjacent tissues, the liability of extension to neighbouring groups of glands, as well as to deep internal glands. is marked. Signs of mediastinal obstruction or pleural effusion are frequent, and large abdominal masses may be felt, from involvement of retroperitoneal or mesenteric glands and from matting and infiltration of intestines. Enlargement of the spleen is found in some cases. Alternatively, and more commonly, the disease may arise primarily within the thorax or abdomen or from lymphoid structures of the pharynx; of these the thymus and the tonsil may be mentioned as examples.

The degree of malignancy in these tumours varies with their detailed histology; in all, the liability to a progressive direct local and lymphatic spread is great and is the more usual course than widespread blood metastasis. Diagnosis from Hodgkin's disease and from other malignant growths can be made with certainty only by microscopic section.

Microscopically, lymphosarcomatous tissue is found to consist of an aggregation of small round cells with scanty cytoplasm and deeply-staining nuclei showing evidence of mitosis and division. Larger cells of endothelial type with convoluted nuclei may also be present, whilst a delicate supporting reticulum accompanies the proliferation, showing many newly-formed blood-vessels and a tendency to necrosis and hæmorrhage. Active infiltration is found through the capsule of the glands into adjoining tissues (fig. 2298).

The remaining common group of cases of multiple gland enlargement to be considered in differential diagnosis is the group of *chronic leukæmias*. In these conditions the patient, usually in middle or later life, comes under observation, not commonly with complaint of

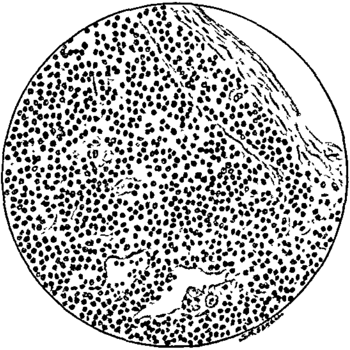

Fig. 2298.—HISTOLOGICAL APPEARANCE OF LYMPHATIC GLAND IN LYMPHOSARCOMA

lymphatic swellings, but rather with symptoms of anæmia or of heaviness and discomfort in the upper abdomen associated with great enlargement of the spleen. Well marked in most cases of chronic lymphatic leukæmia, the splenomegaly is greatest in the chronic myelocytic type, where it may fill the abdomen and press upon the iliac crest and pubes. Local pain may be due to superadded thrombosis with infarction and perisplenitis. The liver commonly shows a similar firm enlargement.

The glandular enlargement, of greater degree in the chronic lymphatic type, has the suggestive feature of a more or less uniform involvement of all peripheral groups of glands, which are enlarged

symmetrically and to approximately the same degree. The glands are soft, discrete, painless and insensitive, and remain freely mobile. The discovery of a non-inflammatory swelling of isolated lymph glands in unusual situations, e.g. pre-auricular, subclavicular or intercostal, should raise suspicion of *chronic lymphatic leukæmia.* In *chronic myelocytic leukæmia* a diffuse enlargement of lymphatic glands also occurs, but is usually slight in degree and considerably less than in the lymphatic type. In both diseases deep groups of glands may show similar affection.

Leukæmia is to be regarded in nature as due to an excessive and unchecked proliferation of a particular variety of leucocyte or its precursor, the ætiology being quite obscure. The affected tissues all show histologically a stuffing of their tissue-spaces with these abnormal cells, replacing to a varying extent their normal structure, while the excess over and above their capacity of storage escapes into the circulating blood. This leukæmic infiltration may become evident in the skin as scattered discrete nodules, especially in the lymphatic form. Diarrhœa may be a feature and is then associated with similar infiltration of the intestine. A slow degeneration of health and secondary anæmia develop, with tendency to hæmorrhage and infection.

The diagnosis of chronic leukæmia and differentiation from other causes of multiple gland enlargement is established by blood examination. In both forms secondary anæmia is evident: in the case of chronic lymphatic leukæmia there is a great increase of total leucocytes, figures of 200,000 per c. mm. being common, of which the vast proportion, 95 per cent or more, are small lymphocytes; in chronic myelocytic leukæmia the total leucocyte count is even higher, perhaps double the figure mentioned, the predominant cells being the granular polymorphonuclears and their precursors in the bone-marrow, the myelocytes, neutrophil, eosinophil and basophil. These granular cells form the majority of the total white cells, although not usually present in such overwhelming proportion as are the lymphocytes in the lymphatic form.

In straightforward cases of chronic leukæmia the diagnosis will accordingly be made with certainty from a blood examination. Difficulty may sometimes arise in the rare forms of so-called "*aleukæmic leukæmia*," in which the general and glandular symptoms and signs are identical with those described, but no increase in the total leucocytes is found, sometimes indeed even a leucopenia. It is thought that the abnormal cells in this case remain confined in the lymphoid tissue and fail to escape into the general circulation. This condition does genuinely occur, usually as a temporary phase of an otherwise typical case of

leukæmia, but sometimes as a persistent state. The diagnosis is aided by a retention of the leukæmic proportions in the differential count, in spite of the total cell count not being raised. In a few cases it may be necessary to remove a gland for confirmatory biopsy, when typical replacement of its normal structure will be found by leucocyte infiltration of appropriate type.

In conclusion, and bearing in mind the difficulties so often met with in the individual clinical case in determining the exact pathology of glandular enlargement, the value of the microscope may perhaps be stressed as a final arbiter. Biopsy is indeed frequently the only means of converting conjecture into certainty.

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CHAPTER IX

THYMUS

by

R. SLEIGH JOHNSON

THE thymus, albeit an organ of much dispute and conflicting views as to its essential nature and functions, is, as a study of its morphology shows, legitimately to be included in consideration of the lymphatic system.

Anatomy and Development. As the thymus is a temporary organ, reaching its maximum development during early childhood and thereafter normally undergoing a progressive absorption, its features are

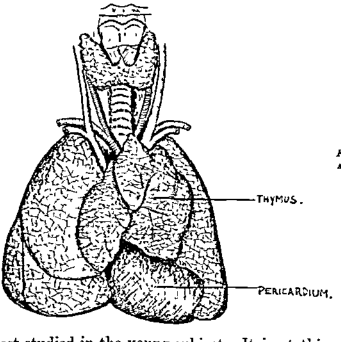

Fig. 2299 —THORACIC ORGANS OF A NEW-BORN CHILD, SHOWING THE RELATIONS OF THYMUS GLAND.

best studied in the young subject. It is at this age a soft, fusiform, lobulated structure composed of two lateral lobes, of which the left is usually the larger, situated behind the sternum and immediately in front of the pericardium, the origin of the great vessels and the trachea (fig. 2299). It frequently extends up into the root of the neck, as high in some cases as the isthmus of the thyroid gland. Laterally, it extends out to the pleural sac on each side, while below, its limit is usually

marked by the fourth costal cartilage, although when much enlarged it may reach down even to the diaphragm. A well-defined fibrous capsule surrounds the organ and sends septa inwards between its composing lobules. In actual size and weight great variation occurs, but an average is given of about 15 grammes at birth; proportionately to total body weight it normally reaches its greatest development between two and four years of age, although its maximum weight may not be reached until or just before puberty, when it is commonly between 35 and 40 grammes. Many factors are, however, concerned, including the relative proportions in the organ of fat or aveolar tissue and the more significant lymphoid tissue; the question is therefore further considered later.

Embryologically the thymus is developed from the endoderm of the third, and occasionally the fourth, branchial cleft, a pair of pouch-shaped diverticula arising from the dorsal aspect of the gill cleft and becoming steadily surrounded by lymphoid tissue. The lumen of these diverticula gradually becomes obliterated by thickening of their walls and an atrophy of their epithelial lining, which by the time of birth becomes represented merely by the concentric Hassall's corpuscles, in the substance of an otherwise solid lymphoid organ.

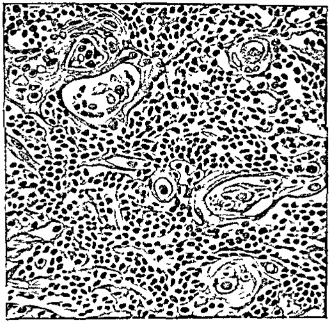

Fig. 2300.—Histological structure of the normal thymus at birth

Histology. The minute structure of the normal thymus is of special importance in view of the type and nature of pathological lesions which may develop. On histological section at the above age (fig. 2300) it is seen to be composed of a collection of lobules,

separated by fine connective-tissue septa. There is no clear subdivision of the lobule, as is sometimes described, into cortical and medullary areas, but each lobule contains a number of more or less discrete follicles of densely aggregated lymphocytes, similar to those of the tonsil or lymphatic gland, and more numerous in the outer zones of the lobule. Interspersed among these collections of lymphoid tissue, and relatively more numerous towards the centre of the lobule, are a number of characteristic nest-like bodies, the so-called Hassall's corpuscles. These show a concentric laminated arrangement of flattened epithelial cells around one or more central cells, the latter often degenerated, and represent the remains of a branching tube-like process of the original embryonic branchial cleft. The corpuscles are themselves surrounded by a rather coarser supporting reticulum than is found in the rest of the organ, thought also to be derived from branchial cleft epithelium. The cells of this reticulum are recognisable by their irregular outlines and large pale-staining nuclei. Eosinophil cells and giant cells are sometimes also found. As regards the bulk of the organ there is no reason to assume that the small, densely-staining round cells are other than true lymphocytes for eventual supply of the blood stream, although their nature has been disputed in favour of their being, like the reticulum cells, primarily epithelial in origin. Thus the thymus in the child consists mainly of an aggregation of lymphoid tissue, while undoubted epithelial elements are represented by Hassall's corpuscles and reticular tissue.

With the progress of atrophy towards adult life, the lymphoid tissue undergoes involution and gradually becomes replaced by fatty and areolar tissue, still containing scattered fragmentary deposits of lymphoid cells, interspersed to a varying degree of density with the epithelial Hassall's corpuscles. These latter tend thereby to become congregated and more prominent, and in some cases to appear more numerous. In others they share in the process of atrophy, until very little of the original glandular substance may remain demonstrable.

Physiology. Differences of opinion have formerly been held as to whether the thymus was to be ranked with the endocrine glands proper, or to be regarded as a specialised lymphatic structure. Although there is no convincing evidence of the production by the thymus of an internal secretion, all attempts to extract such a product having proved unsatisfactory, it is reasonably clear that an interrelation is present between the thymus and the known endocrine glands, in affections of a number of which the thymus becomes enlarged. The persistence of the organ until, and its progressive atrophy after, puberty, coincident with

functional development of the sexual organs and secondary sexual characteristics, is usually ascribed to a retarding influence of the thymus *on the evolution of sexual maturity, until such time as a suitable* degree of general growth and somatic development has been attained. The results of experimental removal in animals, although claimed by some observers to lend support to this theory by hastening sexual maturity, are, however, by no means uniformly in agreement. In view also of the not very infrequent persistence of histologically characteristic, and therefore presumably functioning, thymic tissue long after the changes of puberty or even into adult life, the question of its precise relationship, if any, to gonadic function must still be regarded as an open one.

The view now most widely held as to the probable physiological function of the thymus is to consider it a lymphoid organ belonging to the hæmatopoietic system, and to regard its epithelial elements as vestigial only and not as the source of an internal secretion. This conception finds confirmation in the part known to be taken by the thymus in some generalised affections of the lymphatic system.

PATHOLOGY OF THE THYMUS

Consideration of the pathology of the thymus may best be undertaken under the following headings:

1. *Hypoplasia.*
   (*a*) Normal (included for completeness); (*b*) premature.
2. *Hyperplasia.*
   (*a*) Apparently primary; (*b*) associated with other known diseases.
3. *Vascular Changes and Inflammations.*
   (*a*) Acute congestion and infection; (*b*) chronic infections; (*c*) involvement in inflammatory or hæmatogenous conditions of other systems.
4. *Tumours.*
   (*a*) Innocent; (*b*) malignant.

1. *Hypoplasia.*

(*a*) *Normal.* The *normal* process of involution of the thymus has been already discussed under physiology of the thymus.

(*b*) *Premature.* A pathological involution of the thymus, even a complete atrophy or aplasia of the gland, may be observed at an early age in a number of chronic infections and wasting conditions of childhood, such as infantile marasmus or tuberculosis, or in some cases from no apparent cause. In the former, it results probably from a long-

continued intoxication of the gland, the lymphoid tissue of which atrophies and is replaced by fibrous tissue, producing a densely sclerosed structure with scattered epithelial elements. With this marasmic atrophy of the thymus, other lymphoid tissues such as that of the spleen undergo a like change. No effect on sexual development is known to follow.

2. *Hyperplasia.*

(*a*) *Primary.* An apparently primary hyperplasia of the thymus, forming part of the clinical syndrome known as "*status thymo-lymphaticus*," is, in view of the importance and controversial nature of the subject, discussed separately under that heading (see page 4257).

(*b*) *Secondary.* A simple active proliferation of the thymus gland is known to occur in association with a number of glandular and other diseases. Of these the most important are *Graves' disease, Addison's disease, acromegaly*, and *myasthenia gravis.*

Enlargement of the thymus, sometimes gross, is found almost constantly post mortem in fatal cases of exophthalmic goitre, so much so that some pathologists of the French school formerly regarded the disease as due to a primary disturbance of the thymus, removal of which, rather than of the thyroid, was recommended. From the clinical standpoint, the thymus not infrequently shows sufficient enlargement to give impairment over the manubrium and to cast a characteristic shadow on X-ray examination, and sometimes to account for complaint of dyspnœa and mild dysphagia. The nature of the enlargement is a diffuse hyperplasia of lymphoid tissue, reflected in a moderate swelling of the cervical lymph glands and tonsils and a lymphocytosis in the blood picture. More strictly it may be described as a lymphocytic regeneration of a previously involuted organ, as Hassall's corpuscles are rarely present. The overgrowth is one which usually subsides after surgical treatment of the thyroid, and responds readily to the application of deep X-rays if this is required.

The hyperplasia seen in some cases of Addison's disease and acromegaly is of similar nature and is of no clinical importance. In myasthenia gravis the relationship is more significant, some abnormality of the thymus being found in a high proportion of cases. It may here be a simple hyperplasia, or a tumour such as a lympho-epithelioma of the thymus. The causal relationship, if any, is not understood. Removal of the enlarged thymus has been advocated in treatment.

3. *Vascular Changes and Inflammations.*

(*a*) *Acute congestion* of the thymus, sometimes with hæmorrhage into the gland, is found in a number of acute infections, especially in

broncho-pneumonia, and may be only an asphyxial phenomenon. Of surgical importance is the occasional acute congestion of the enlarged thymus following operations upon the thyroid in exophthalmic goitre, which may be productive of symptoms otherwise obscure.

Primary acute infection of the thymus has not been described, although the organ may become secondarily involved in any acute inflammatory condition of the mediastinum; suppuration may then occur.

(*b*) *Chronic infections.* Tuberculosis and syphilis of the thymus are both pathological rarities. The thymus may react to a number of chronic infections, either by hyperplasia of its lymphoid tissue or by atrophy and sclerosis. None of these conditions is of clinical importance.

(*c*) In diseases directly involving the lymphatic systems, such as leukæmia or lymphadenoma, the lymphoid tissue of the thymus may take part in the general response, in characteristic fashion with the remaining lymphoid structures of the body.

4. *Tumours of the Thymus.*

Primary tumours of the thymus are of less infrequent occurrence than would be inferred from customary accounts. If conditions of simple hyperplasia be excluded, innocent tumours are, however, rare and of little practical importance. The majority of thymic neoplasms show evidence of malignancy, varying from a low-grade local invasion to the most rapid and widespread metastasis.

Innocent tumours. Benign neoplasms include *lipomata, fibromata, dermoid cysts*, and *simple cysts* thought to originate from degenerated Hassall's corpuscles or from occasional inclusions of thyroid tissue. The term " thymoma " conveys no histological indication and its use is not therefore recommended.

Malignant tumours. The classification of primary malignant neoplasms arising in the thymus presents considerable difficulties, owing to lack of agreement on the part of various observers as to the histogenesis of the normal organ and the differences in nomenclature adopted.

The most useful classification would appear to be that put forward by Maximov in 1931, which is based upon the theory of development of the thymus outlined earlier in this section. The small rounded cells of the gland are regarded as derived from perivascular mesenchymal lymphocytes, which at an early stage wander into the primitive epithelium of the thymus. This cylindrical epithelium of entodermal origin becomes modified in character and converted into a reticulum-cell mass, and in the deeper portions of the gland into Hassall's corpuscles. The reticulum cells can be identified in a section by a special

method of staining which reveals fine argentophil fibres, for the most part concentrated around the blood-vessels.

On this histological basis of development, *malignant thymic tumours* may be classified as follows:

(1) Arising from the capsule and interlobular connective tissue—*spindle-celled sarcoma.*

(2) Arising from the reticulum cells and Hassall's corpuscles—*carcinoma.*

(3) Arising from the lymphocytes—*lymphosarcoma.*

Critical study of published cases by McDonald in the light of this classification has shown that a large proportion of thymic tumours

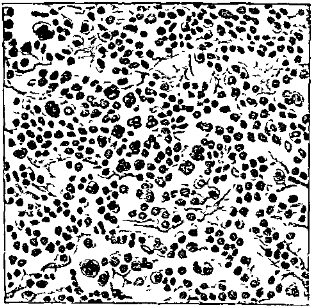

Fig. 2301.—PRIMARY RETICULUM-CELLED CARCINOMA OF THE THYMUS—HISTOLOGICAL STRUCTURE. (*Author's case.*)

previously interpreted as primary sarcomata have, in fact, a *common type cell* with strong morphological resemblance to the reticulum cell of the normal gland, and are most probably *reticulum-celled carcinomata* (fig. 2301). Confusion and difficulty arise from the markedly pleomorphic nature, both of these cells themselves and of their arrangement. The type cell is a large, irregularly rounded or polyhedral cell, which may be arranged in some cases in solid alveolar masses resembling a medullary adeno-carcinoma, in others in a stellate arrangement forming a loose anastomosing reticulum. Sometimes both types of formation are present in different areas of the same tumour, while giant cells, keratinised cells, or irregular calcified deposits may be evident. Again, transitions may be found to a flattened type of cell arranged in concentric whorls resembling the normal corpuscles.

It is thought that these variants arise from a primary proliferation respectively of the cells of Hassall's corpuscles and of the thymic reticulum, forming the common *alveolar* and *reticular type* of carcinoma. The striking histological feature of this variety of new growth is the extreme degree of variability. The type cell is sometimes spindle-shaped rather than rounded, although still a variant of the epithelial reticulum cell, while Hassall's corpuscles or their representations are by no means always to be found. The clue is, however, usually given by the discovery on search of at least some more fully differentiated types comparable with the normal cell.

Together with these epithelial constituents of the tumour are found aggregations of lymphocytes, again in a varying proportion. The admixture may be small, with preponderance of epithelial cells, or, on the contrary, lymphocytes may predominate, and epithelial elements be scanty. In the latter case they may sometimes be overlooked altogether, and an erroneous interpretation made of the tumour as being mainly sarcomatous. The lymphocytes tend, as in the normal organ, to show a perivascular distribution, and may be accompanied by plasma cells and eosinophil cells.

The predominance in some cases of lymphocytes has led to an alternative classification by Babes and by Matras and Prieskel in which these tumours are designated as *combined lympho-epithelial neoplasms* attempting to reproduce the entire structure of the thymus by the formation of reticulum cells and Hassall's corpuscles together with the lymphoid tissue. The variations in type are classified as under:

(1) *Pure epithelial tumours.*

(2) *Lympho-epithelial tumours.*

  (*a*) With *preponderance of epithelial type of cell* and admixture of lymphocytes in varying degree, these being limited to the perivascular region.

  (*b*) With *preponderance of lymphoid cells* and marked deficiency of epithelial elements. In this type the epithelial cells form part of the reticulum of the tumour, constituting a subdivision to which the term *lympho-reticular carcinoma* is sometimes applied.

Ewing holds the view that thymic carcinomata originate in connection with portions of involuted thymus, and that such tumours are frequently of the nature of infective granulomata, on the analogy of Hodgkin's disease, or of neoplasms consequent upon such granulomata. This latter view, however, has not received general support.

The symptoms of these malignant tumours of the thymus are usually local, and are confined to the pressure effects of the growth or its metastases, but Leyton, Turnbull and Bratton have described the occasional association of thymic carcinoma with pluriglandular disturbances, while Wu has noted the co-relation of lympho-epithelioma with myasthenia gravis.

No special description is called for of the histological features of truly sarcomatous and lympho-sarcomatous tumours arising in the thymus, these being identical with those found in other organs.

MACROSCOPIC AND CLINICAL FEATURES OF THYMIC CARCINOMATA

Although occurring at any age, these tumours are of most frequent incidence between the ages of 20 and 40 years, and are commoner in the male sex. The onset is usually gradual, with symptoms of unproductive cough and dyspnœa, from pressure upon the trachea, while, with extension of the growth, adjacent structures may similarly be obstructed or invaded. Cyanosis, with venous engorgement of the head and neck, may become marked from pressure upon the superior vena cava, with distension of surface veins and œdema of the chest wall or upper limbs. Stridor and pulmonary collapse may develop, and frequently a recurrent blood-stained effusion. In two of my own cases, the diagnosis was, however, obscured by the coincidence at onset of high intermittent fever with clear, sterile pleural effusion containing a predominance of lymphocytes, thought at first to be tuberculous, the true ætiology only being suspected later by persistent recurrence of fluid and heavy admixture of blood, increasing dyspnœa unrelieved by tapping, and development of œdema of one arm; post-mortem examination in each case revealed a large reticulum-celled carcinoma of the thymus with extensive metastases over pleura and diaphragm.

Pressure may occur upon nerves such as the phrenic, recurrent laryngeal or vagus, with hiccough and alterations of voice and of pulse-rate. Less often dysphagia results from posterior dislocation of the œsophagus. Pressure upon or direct invasion of the subjacent pericardium may give rise to excessive tachycardia from displacement or pericardial effusion.

The rapidity or otherwise, and the extent of development, of symptoms such as the above will vary greatly according to the degree of malignancy and rate of growth of the tumour, and in keeping also with its naked-eye features and tendency or otherwise to metastasise. In many cases growth is slow and only locally malignant. The tumour forms a firm, sometimes hard, mass filling the anterior mediastinum, and

is lobulated or nodular, with a varying attempt at encapsulation. On naked-eye section it is fleshy in appearance, and markedly vascular, often showing areas of hæmorrhage or of degeneration. The adjacent thymic tissue is compressed or replaced, and invasion may or may not have taken place through the fibrous capsule of the gland into adjacent structures. In some slow-growing tumours, the growth may long remain strictly localised to the thymus without spread to other structures. In other cases, with more rapid growth, the tumour is softer, perhaps friable and necrotic, greyish-red, shows no delimitation by a

Fig 2302.—PRIMARY CARCINOMA OF THYMUS, ILLUSTRATING MACROSCOPIC APPEARANCES. THE TUMOUR TISSUE HAS BEEN CUT AWAY FROM THE ANTERIOR ASPECT TO SHOW THE POSITION OF THE HEART, AND THE WIDESPREAD INFILTRATION OF THE PERICARDIUM, WITH EXTENSIVE SECONDARY DEPOSITS OVER THE PLEURA AND DIAPHRAGM. (*Author's case.*)

capsule, and may form a huge mass in the upper thorax and neck, infiltrating all adjacent structures and metastasising widely in lymphatic nodes and viscera. The lymph glands involved are usually the mediastinal, cervical and axillary; the visceral metastases are in most cases confined to the pleura, lung and diaphragm, but may invade the liver, kidney, spleen or distant organs as well as the long bones. The total duration of disease may be a matter of weeks, while the majority of cases prove fatal within a year, commonly from respiratory obstruction.

DIAGNOSIS OF THYMIC NEOPLASM

Clinical differentiation of tumours of the thymus from mediastinal neoplasms in general is in any case difficult, and for the most part

impossible. It is suspected from the symptoms already enumerated of pressure in the anterior mediastinum. Suspicion would be confirmed by localised dullness to percussion over the upper sternum, perhaps a visible local protrusion of the chest wall, marked venous distension, and suggestive appearance on X-ray examination.

Radiological investigation should be made in any case of suspected enlargement of the thymus from whatever cause. An opaque well-defined shadow in the anterior mediastinum, extending downwards and laterally and overlapping the heart shadow in front on each side, is suggestive of a thymic origin. Where the rare circumscribed tumour or cyst of the thymus is present, this may be evident from the definition or shape of the shadow.

General examination of the patient and special pathological investigations, such as biopsy of a lymph gland, a blood count or Wassermann reaction, will aid in excluding inflammatory conditions such as Hodgkin's disease or aneurysm.

Treatment. The majority of thymic tumours, from their position and malignant characteristics, are unfortunately not amenable to surgical removal. In these cases treatment will consist in symptomatic relief, where possible, of pressure effects, as from pleural effusion, together with deep X-ray or radium-bomb therapy to the affected area. Radiotherapy is usually only palliative in its effects, but appears to be temporarily most helpful in the group of sarcomata.

Where the evidence points towards a localised neoplasm of the thymus, attempt may be made, in some cases successfully, at surgical removal, either from above through the root of the neck or after longitudinal splitting of the sternum.

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CHAPTER X

Status Thymo-Lymphaticus

by

R. Sleigh Johnson

In the consideration of thymic affections outlined in the preceding chapter, discussion was omitted of the syndrome reputed to result from simple hyperplasia of the organ and of other lymphoid tissues, to which has been given the name "status thymo-lymphaticus." Special consideration is merited in view of the controversy which still persists among many authorities even as to its claim to be regarded as a separate entity. Certainly the use of the term has been abused in its being made to cover up much pathological uncertainty and ignorance on the subject. A review of recent critical analyses and of the present state of knowledge, considered jointly with historical conceptions of the condition, may be helpful therefore towards an understanding of the problem.

Briefly, the syndrome, as described, relates in the main to the occurrence of sudden, dramatic death in apparently trivial circumstances. That this occurs not infrequently is beyond dispute and is a matter of general experience. A child, for example, previously considered fit, ceases breathing and abruptly dies for no obvious reason at the commencement of anæsthesia for a trivial condition, such as tooth extraction or, say, prior to tonsillectomy. A careful autopsy reveals no adequate explanation, the vital organs being to all appearances healthy; there may, however, in a proportion of cases be found unusual features of bodily structure and physique, together with apparent prominence of the thymus. The latter is seized upon as a suitable scapegoat and is made to explain an otherwise mysterious death, chiefly to satisfy legal demands. The difficulties in arriving at a truthful explanation are concerned not so much with the facts, which are not in dispute, as with their interpretation as to which are causal and which merely associated or incidental.

From the historical standpoint, much investigation was made to elucidate any factors in physique or build common to those who underwent sudden death in unexplained circumstances. Paltauf in 1889

was the first of modern investigators to implicate the thymus in its causation, although this had been noted in the literature as early as the beginning of the eighteenth century. While considering enlargement of this organ as the primary and invariable factor, however, he was careful to point out associated general changes, such as vascular hypoplasia, including that of the aorta, diffuse overgrowth of lymphoid structures, a fat flabby build and a tendency to feminism. To this combination of features he gave the name "status thymo-lymphaticus."

Symmers, at the Bellevue Hospital, New York, from a study of 4000 unselected post-mortem examinations, described the condition as follows: "A combination of hereditary constitutional anomalies, entering into which are certain peculiarities of configuration, with preservation or even hyperplasia of the thymus gland at an age when involution is to be expected, hyperplasia of the lymphoid cells in the lymph nodes, spleen, intestine and elsewhere; hypoplasia of the cardio-vascular system, developmental deficiencies in the genitalia, and, incidentally, visceral defects of uncertain occurrence and irregular distribution."

The overgrowth of lymphoid tissue was stated to be evident in the tonsils, tongue and naso-pharynx, in the cervical, axillary, mesenteric and inguinal glands, in Peyer's patches and in solitary follicles of the intestine and mucosa of the appendix. Enlargement of the spleen was found to be unusual, but lymphoid hyperplasia was present within the organ. Hyperplasia of the thymus he regarded as being constant, although in only half of his described cases was the weight of the organ recorded. The histological change common to all the enlarged organs was a marked, active proliferation of lymphocytes. Symmers described 6·2 per cent of his total of 4000 post-mortem cases as belonging to this type, in which males predominated by six to one.

Hyperplasia of the thymus, before full description of this syndrome, had long been held to account not only for sudden and unexplained death, but also for disturbances in childhood of lesser severity, characterised chiefly by dyspnœa and originally graded by Warthin as "thymic stridor" and "thymic asthma" respectively. The former, as described, consists of attacks of stridor in the first few months of life, coming on especially after a screaming fit or throwing back of the head, severe bouts being accompanied by signs of respiratory obstruction such as intercostal recession. "Thymic asthma," so-called, is but a further degree of paroxysmal dyspnœa of inspiratory type, with cyanosis or greyish pallor of the face, distended cervical veins, and intense overaction of accessory muscles. Unless relieved, collapse is

liable to follow, with flaccidity, dilated pupils, feeble heart sounds, and death. In both groups, symptoms were ascribed to mechanical pressure upon the trachea by enlargement of the thymus, although such stenosis could by no means frequently be demonstrated post mortem.

The work of Paltauf and Symmers stimulated interest, and many further cases were put on record of sudden death with reputed thymic enlargement, so that for a number of years this easy though inadequate explanation received tacit acceptance. Subsequent analysis of these and similar publications, however, showed that observations made therein upon the thymus assumed to be pathologically enlarged were based on widely varying standards of normality as regards size and weight of the thymus in health at different ages and periods of growth. Hammar in 1926, in an exhaustive study, first put these standards upon an established basis, indicating the variations in the weight of the organ which must be accepted as within the physiological range in relation to age, sex, height, body weight and weight of other organs. Although rough approximations were found between which the majority of normal figures lay, nevertheless wide limits, up to some hundreds per cent, were found occasionally to be compatible with normal health and unassociated with symptoms of the "thymic syndrome."

When put to the statistical test, the case for hyperplasia of the thymus *per se* being responsible for sudden death was found to break down. Some further and wider explanation had to be sought for. Observations were continued by Greenwood and Woods, and jointly with them by Professor Turnbull, to discover, by analysis of a very large series of post-mortem examinations on young subjects, whether these high deviations from the average figure for weight of the thymus occurred any more frequently in cases of reputed "thymic death" than in death from any other unselected cause, as, for example, from accident. Their conclusions, though largely negative, nevertheless threw some light on the question. Taking the weight of the organ alone, although they found no general tendency to an increase in size, that is, to hyperplasia, of the thymus in the former group, they were able to demonstrate a greater degree of variability in weight around the mean figure in those cases where sudden death had occurred than in the control group. The probability of the organ being either larger or smaller than the average for that age was greater in the former group than in cases of death from other causes. Their conclusion on the theory of hyperplasia was that the terms "status lymphaticus" and "status thymo-lymphaticus" were "mere verbalisms."

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In view of the importance of these observations, in 1926 a joint committee of the Medical Research Council and the Pathological Society of Great Britain and Ireland was established to investigate the problem still more closely. Their broad conclusions confirmed the opinions of the previously named observers in finding no evidence that the so-called "status thymo-lymphaticus" existed as a pathological entity.

The problem thus became increasingly complex and still unsolved. No positive evidence having been deduced regarding a constant abnormality in size or weight of the thymus, attention was directed to possible significant factors in the minute structure of the gland, a direction of study included by Hammar in his analyses. He investigated the organ from the aspect of the degree of proliferative or involutional changes present, taking as indices the relative proportions to one another in the gland of Hassall's corpuscles of differing sizes. These "Hassall's ratios" were obtained by classifying the corpuscles into three groups according to diameter. With this as criterion of internal structure, analysis by Greenwood has shown an interesting analogy with his observations on total weight. While no significant difference is found in the average figure of the two groups as regards the size of Hassall's corpuscles, nevertheless a greater degree of variability around the mean figure could again be demonstrated, taking the group as a whole rather than individual cases.

To summarise, the evidence regarding the thymus in these states which is justified by critical analysis indicates, therefore, a degree of instability of the organ in weight and structure, to be interpreted with most probability not as causative, but merely as part of a generally greater instability of the body as a whole.

With the disproving of a primary part played by an enlarged thymus, the theory of a fatal result being brought about by pressure on the trachea or vagus has to be abandoned. Death, moreover, in these cases is too sudden to be due entirely to asphyxia. A theory which appears more reasonable is that death occurs from a form of *anaphylactic shock* with sudden vagotonia and cardiac inhibition.

This theory has been studied fully by Symmers among others, taking a wider view of the syndrome and anatomical changes. He described two anatomical types: firstly, a condition of "*status lymphaticus*," with well-marked lymphoid hyperplasia throughout the body, including often a lymphocytosis in the blood and an accompanying susceptibility to anaphylaxis, urticaria, asthma, convulsions, and (rarely) sudden death, together with a lowered threshold to infection

and defective development of the muscular coats of the arteries; and, secondly, a condition of "*recessive status lymphaticus*," in which bodily configuration remains unchanged, but involutional atrophic changes have occurred throughout the lymphoid tissues. In this second group, as the lymphoid structures undergo involution so the tendency to anaphylaxis diminishes and with it the danger of sudden death. The first group predominates in childhood and tends with adolescence to pass into the second.

The theory is supported by the microscopic changes he describes in the lymphoid tissues in cases where sudden unexplained death has occurred. In such cases he has found abundant areas of necrosis in the germinal follicles of the lymphoid tissues throughout the body. These are present in all stages both of the necrotic and of the reparative phases, the former predominating. His theory is that the hyperplastic lymphoid tissue, especially in the naturally exposed situations of the upper respiratory and gastro-intestinal tracts, is subjected to repeated minor chemical and toxic trauma, to which it reacts by focal necrosis; that in this process a specific nucleo-protein is liberated to which the lymphoid tissues become sensitised. Subsequent exposure to the stimulus produces further necrosis and liberation of toxin, with an anaphylactic reaction varying according to the intensity of stimulus, which reaction, if marked, is shown by sudden death.

Such a theory, though admittedly hypothetical, at any rate goes further to explain the known facts than any other so far put forward, and links together the minor and major manifestations into a single conception.

It remains to refer to the operative risk and to discuss what prophylactic measures, if any, are to be adopted where the need for caution is suspected from the clinical type. In a fat, flabby male child with palpable glands and enlarged tonsils, especially if a blond, operation should be undertaken only if really necessary, and any catarrhal infection of the upper respiratory tract first treated with thoroughness. Emotional excitement, excessively strenuous exercise, and extremes of temperature in bathing should be avoided, and any evidence of rickets given appropriate treatment. If radiological examination shows a large thymic shadow, cautious X-ray treatment to the gland region is indicated prior to operation. Some estimation of the need for caution is to be obtained from a differential blood count, the danger of anaphylaxis being the greater in proportion to the percentage of lymphocytes present, since the latter may be accepted as a more or less reliable index of the degree of general lymphoid hyperplasia in the body.

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PART XXIII

ORTHOPÆDICS

by

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PART XXIII

ORTHOPÆDICS

by

ST. J. D. BUXTON

INTRODUCTION

CHAPTER I

Amputations

CHAPTER II

Operations on Joints

CHAPTER III

Tumours of Bone

CHAPTER IV

Fractures

In conjunction with H. L.-C. WOOD

ORTHOPÆDICS

Introduction

In Volume II of this work (Part XVI), under the comprehensive title of "Orthopædics," the following subjects were discussed: Deformities of the Feet; Disabilities of the Knee Joint; Acute Osteomyelitis; Acute Arthritis; Open or Compound Fractures; Muscle and Tendon Injuries; and The Surgery of the Peripheral Nerves.

This part is a continuation of the subject, and I have here described in some detail: Operations upon the Joints; Tumours of Bone (with special reference to Sarcoma); and those aspects of Fractures not dealt with in Volume II. The value of certain operations for Tuberculosis of the Joints is described, but no attempt has been made to discuss the routine treatment of any one joint affected with this disease. A detailed account of Amputations and the Operative Procedures upon Joints is given, the former because it is important and the latter on account of the definite advances that have been made in this branch of surgery during the past twenty years.

In subsequent editions of this work the whole subject of Orthopædics will be incorporated in one single volume.

CHAPTER I

Amputations

The term *amputation* is employed when an operation is performed to remove a portion of a limb by dividing the bone, whereas *disarticulation* indicates division through a joint.

Injury and disease of a limb are clearly the causes for which amputation is required, and there is no intention of discussing in any detail the indications for each operation. However, it is most important for the surgeon to appreciate that, in deciding the level of amputation, he should consider not only the damaged or diseased portion of the limb, but also the production of a stump which will be able to fulfil a useful function. When amputation is carried out as a life-saving measure, or near an infected area, it may not be possible to give as much consideration to the stump as in a "set operation." At times, amputations will be carried out as a preliminary operation, with the realisation that when life has been saved and infection is absent, a set operation may be necessary to make a satisfactory stump. However, if the emergency operation is carried out with thought as to the level of bone division, and skill with regard to the division of skin and muscle, the second amputation will often not be required.

A knowledge of artificial limbs will assist in deciding which will be the most satisfactory stumps produced by the various types of amputation and disarticulation.

AMPUTATION STUMPS

In *both upper and lower limbs*, it is advisable for:

(1) The skin over the end of the stump to fit neatly without undue tension; (2) the scar to be painless and placed so that it does not become rubbed or pressed upon by the artificial limb; (3) the shape to be regular with no irregular bulges at the end of the stump; (4) the end of the bone to be well covered by soft tissues; (5) the whole stump to be painless; (6) the divided nerves to be painless; and (7) the joint above the stump to be painless and have a full range of movement.

In the *lower limb*, the stump either has to bear weight directly—end-bearing—as in Syme's amputation, or it is used as a lever when

weight-bearing is taken by bony prominences above the stump. This is exemplified by: (*a*) Mid-leg amputation, when the bucket of the artificial limb fits against the head of the tibia and the lower border of the patella, and the leg stump is the lever; and (*b*) supracondylar amputation, when weight-bearing is taken by the tuber ischii, and the thigh stump acts as a lever (fig. 2303).

Sacrifice of some length of limb is often advisable in order to produce

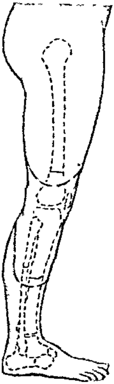

Fig 2303.—Diagram showing the two best amputations of the lower limb. The shape of the stump and the line of bone section are indicated in each case.

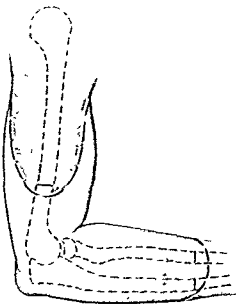

Fig 2304.—Diagram showing the two best amputations of the upper limb. The shape of the stump and the line of bone section are indicated in each case.

a stump satisfactory for weight-bearing and thus for function. A scar at the end of the stump or an adherent scar is undesirable.

In the *upper limb*, weight-bearing is not required, and the function of the stump is limited to the transmission of movement, so that objects can be moved and held.

Every effort should be made to provide as long a stump as possible, but the situation of the scar is of little importance provided the flaps are cut so that the scar has a good circulation and does not tend to ulcerate (fig. 2304).

Particular attention to the technique of dealing with the nerves is of paramount importance.

TECHNIQUE OF AMPUTATION

A *tourniquet* is used as a routine measure, and is placed as far above the site of operation as possible. It is contra-indicated when the blood-vessels are calcified, and cannot be employed in amputations and disarticulations about the shoulder and hip joints.

Skin flaps. The total length of the flap or flaps should be that of the diameter of the limb at the level of bone section. Sometimes a shorter length is sufficient, as in the thigh where skin stretches readily. The old rule of " a diameter and a half " produces a loose flap, and was formulated when retraction of skin followed granulation of the wound. The type of flaps cut differs in various countries and also amongst surgeons in this country. It is advisable to be conversant with the recognised methods of cutting flaps, for each type is useful in some portion of a limb.

The *circular* skin flap is suitable for portions of a limb that are more or less cylindrical. It is usually modified by two lateral vertical incisions, which really convert it into two equal flaps.

The *elliptical* skin flap is little used in this country, but is suitable for portions of a limb that are conical. This may be converted into a *racket incision* by adding a vertical incision from the highest point of the ellipse.

The *flap method* means the cutting of two rectangular or semi-circular incisions (either equal, or with one flap larger than the other) or of a U-shaped flap of skin from one surface. These flaps should be from the flexor and extensor surfaces (i.e. anterior and posterior) rather than lateral flaps. As a rule, the longer flap should be cut from the extensor surface. The subcutaneous tissue should be included in the skin flap and not separated from the skin. If there is an excessive amount of fat, it is advisable to remove some of the deeper portion of this.

Muscle and muscle sheath. As a general rule, these should be divided at right angles to the long axis of the limb and below the line of bone section. Tendons should be divided at a similar level and not withdrawn from their sheaths. It is advisable to allow sufficient muscle to cover the end of the bone and make a regular-shaped stump. If too much muscle is left the stump is unnecessarily bulky. In certain amputations, such as those directly above the knee joint, a good covering for the bone is obtainable by including the muscular and aponeurotic tissue in the skin flap, but this is not desirable as a general principle. The attachment of tendons to the flap or scar is undesirable.

Bone and periosteum. Muscles should be retracted by an assistant holding an efficient muscle retractor or device which enables the operator to see the bone clearly and prevents muscle tissue from coming

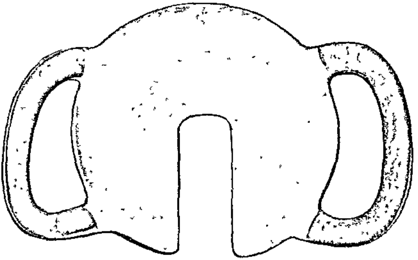

Fig 2305—MUSCLE RETRACTOR SUITABLE FOR USE IN AMPUTATION OF THE THIGH.

in contact with the saw (fig. 2305). The periosteum is divided with a knife just above the proposed line of bone section and is gently pushed upwards (fig. 2306). The lower cuff is pushed downwards, and the bone sawn through at right angles to its long axis. If any prominence remains owing to the bone being irregular in shape (e.g. the tibia), this prominence is rounded off, or it can be sawn partly through before the bone is divided. If this method of dealing with periosteum and bone is followed in clean amputations, the end of the bone will round off and the end of the medullary cavity become covered with compact bone. If the end of the bone is covered with periosteum or a flap of bone covered by periosteum (osteoplastic), there is a likelihood of the end of the bone becoming thickened and of spur formation taking place.

Fig. 2306. — THIS PICTURE INDICATES THE RESULT OF REFLECTING THE PERIOSTEAL FLAP; THE APPROPRIATE LINE OF BONE SECTION IS SHOWN.

Hæmorrhage. The main blood-vessels are divided transversely and neatly, and are picked up singly with artery forceps. Others visible are dealt with similarly, and each is ligated in turn with catgut. Non-absorbable material tends to form a nodular scar and, in the presence of sepsis, acts as a foreign body. When all visible vessels have been ligated, the tourniquet is removed and other vessels are picked up and tied. A basin of sterile saline at 120° F. is then placed beneath the stump and the wound bathed. This will arrest oozing and make

a number of smaller vessels more visible. When it is realised that the *main vessels* are *calcified* it is unwise to use a tourniquet, as this may injure the artery and therefore damage the blood supply to the peripheral part of the stump. As digital compression may have a similar detrimental effect, it is advisable to proceed deliberately by picking up the vessels bleeding after division of the skin, and then to cut down to the main vessels and pick them up with artery forceps before division. Other large vessels can be dealt with similarly. In particular amputations, such as disarticulation at the hip or shoulder, a tourniquet cannot be used and it is expedient to cut down on to the main vessels and ligate them above and below the place where they are to be divided, before proceeding further with the amputation.

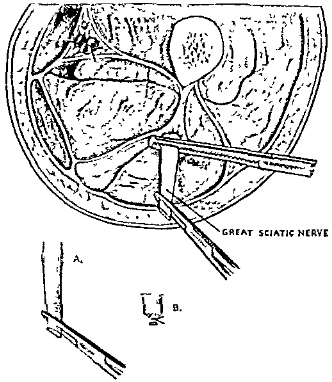

Fig 2307.—Diagram showing method of division of a nerve in an amputation. The great sciatic nerve is pulled down and clamped.

A. Shows effect of clamp on nerve.

B. Shows ligation through area clamped.

Nerves. When the blood-vessels have been ligated, each nerve in turn is pulled down by traction with forceps. A strong pair of artery forceps is then placed at right angles to the nerve and as high up as possible. The nerve is well crushed and a catgut ligature placed round the nerve at the crushed point. The nerve is then divided just below the ligature (fig. 2307). The object of this is to confine to the inside of the sheath new axis cylinders which form, thereby limiting the size of the pseudo-neuroma and adherence to surrounding structures.

The injection of formalin, alcohol, novocaine, or other fluids is not advocated.

Closure of the wound. Muscles and their sheaths are stitched together over the end of the bone to cover the divided area, obliterate dead spaces, and give the desired shape to the stump. A rubber drainage-tube with a safety-pin through one end is inserted with one or both ends protruding at the lateral edges of the scar. The skin and subcutaneous tissue are sutured accurately with a number of strong interrupted sutures, and then with a fine continuous stitch. The stump is covered with a large dressing of gauze and wool and firmly bandaged with a 6-inch gauze roll, after which another layer of wool is bandaged on. A piece of elastoplast is then placed in the long axis of the limb to prevent the tendency of the dressing to come off the end of the stump. The stump is then placed on a small pillow. In lower limb amputation a thin towel is spread over the stump and pillow and fixed by sand-bags.

After-Treatment. The drainage-tube is removed in forty-eight hours. This can often be accomplished without removal of the whole dressing, which saves the patient both pain and anxiety. After this the stump is left free on the pillow. The skin sutures are removed in ten days and the patient is encouraged to move the stump. He gets out of bed when the sutures are out in the case of upper limb amputations, and after three weeks in lower limb amputations. The stump is kept firmly bandaged, but movement is encouraged, so that it does not become flexed at the joint proximal to the amputation. This is particularly important in thigh amputations.

Kineplastic amputation. Attempts have been made in upper limb amputations to adapt the ends of the bones, muscles and tendons so that they have direct control over mechanical contrivances, without the use of an artificial limb. The lower end of the forearm has been the area of choice for this type of operation, but ingenious as have been the operative procedures, the function produced has been in most cases useless.

AFTER-TREATMENT OF AMPUTATIONS

A week after the wound is healed the stump should be washed with soap and water, dried, dehydrated with spirit, and powdered. It should be massaged daily, and the patient encouraged to move the proximal joints. A firm bandage will be comfortable, preserve the shape, and help the shrinkage.

In the case of the lower limb, it is most important to get the patient out of bed, both using crutches and wearing a pylon as soon as possible. This is to prevent flexion deformity of the knee in below-knee amputations and flexion-adduction deformity in thigh amputations.

A pylon consists of a bucket made of plaster from a cast and lined with felt at pressure points. The bucket is fixed to hickory sticks as is shown in figure 2308.

This apparatus enables the patient to learn to balance, usually using one crutch, and keeps the stump mobile. As the stump shrinks, a new bucket can be made, and when the stump has reached a stable condition a permanent artificial limb

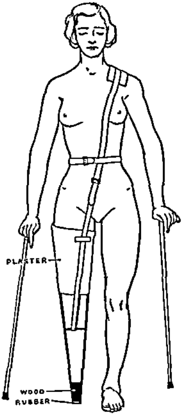

Fig. 2308.—Patient walking with a pylon suitable for a case of thigh amputation. The bucket is of plaster lined with felt. The uprights are of hickory. A webbing strap passes over the shoulder of the opposite side, which is protected by a felt pad. The patient uses two sticks.

is provided. The patient learns how to use the more complicated apparatus with far less difficulty after six months' use of a pylon.

Skin irritation or infection of a stump always requires attention, and the artificial limb should not be worn until it is relieved.

COMPLICATIONS IN AMPUTATION STUMPS

Conical stump. This arises: (1) in childhood from growth of the bone within the stump, or (2) from retraction of muscles cut too short at the time of primary amputation.

(1) This complication cannot be prevented. Owing to the situation of the "growing end" of the bone, it is seen most frequently after *amputation through the arm or leg in children. An early re-amputation* will be followed by a further conical stump, unless a long piece of bone is removed and very amply covered by soft tissues. Unfortunately, if the conical stump is left indefinitely, the tissues over the end of the bone gradually become thinned until ulceration of the skin may occur. It is advisable to delay the re-amputation as long as possible, and if it

has to be done before the age of sixteen ample covering must be placed over the end of the bone. Any operative procedure on the metaphysis, where the new bone formation is occurring, which aims at stopping this growth is to be condemned in the case of the conical stump, as it is impossible to ensure cessation of growth in a regular manner. It is inadvisable to operate on the base of a stump, where pressure often occurs from the artificial appliance, and the risk of producing deformity there is greater than is the chance of an eventual good stump by the method already suggested.

(2) A conical stump in an adult necessitates re-amputation if the artificial appliance is not working efficiently or if there is pain or a tendency to ulceration over the end of the stump. It is advisable to operate at a time when there is no granulating area over the end of the bone, and the operation is carried out on the lines of an amputation at a higher level.

Scar tissue. If there is a painful scar, particularly at a pressure area of the artificial limb, this should be excised. Often there is thickened rough skin and alteration in the vascularity around such a scar. The artificial limb should not be worn for three weeks or so prior to operation, and the skin should be cleansed and softened. If possible, a wide area of skin including the scar should be removed and the suture carried out accurately. Advantage is often gained by closing the wound in such a way that the new scar lies in a different position from that of the old painful area.

Painful neurofibroma. This arises from imperfect technique in dealing with a nerve at the primary amputation, and often after amputations carried out through infected areas. The nerve bulb and 1 inch of nerve above should be exposed through an incision in a line with the nerve. The nerve proximal to the bulb is freed and traced down to the bulb, which is dissected from the surrounding fibrous tissue (see fig. 2309). This is then grasped firmly with strong hæmostats and the nerve pulled down. The nerve is then crushed and tied off, as described under Technique in dealing with nerves. It should be possible to crush it 2–3 inches above the bulb. Experience after the War showed that the new nerve bulb formed was sometimes painful, even when the secondary operation was carried out with due care. It is suggested that this was due to a chronic inflammatory condition present in the nerve, and that the tendency was for the bulb to get less tender after some months, whereas injections of alcohol or other fluid were inclined to irritate the nerve structure and increase the symptoms.

Spurs. Spur formation may occur at the end of the bone. A spur

results from ossification in muscular or tendinous tissue attached to the edge of the end of the bone. The rough stripping up of periosteum, particularly in the presence of mild infection, may be the primary cause. A spur can often be prevented by cutting away the periosteum proximal to the line of bone section, and by dividing the muscular attachment to the bone for an inch above the end of the stump (e.g. muscular attachment to linea aspera in thigh amputations).

The existence of a spur, found on palpation in a stump not well covered, or seen in a skiagram, does not call for treatment unless it is

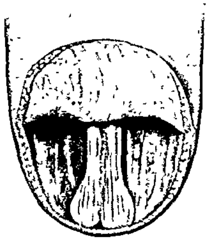

Fig. 2309.—An amputation stump with a flap turned up to expose two neuro fibromata, adherent to one another and to the subcutaneous tissue and skin. (*Museum, King's College Hospital*).

Fig. 2310.—The distal three inches of the femur removed from a septic amputation stump in which a sinus existed. A sequestrum is shown in a cavity in the bone. There are cloacæ, such as are found in chronic osteomyelitis.

painful. In removing a spur care must be taken to avoid rough treatment of the bone, periosteum and muscular attachments, or else another spur may form; when a number of spurs are present round the end of the bone, it may be advisable to remove the distal $\frac{1}{2}$-inch of the amputated bone with the spurs attached.

Sinus in a stump. A persistent sinus indicates infection around a foreign body, which is usually a piece of non-absorbable ligature or a sequestrum, or, rarely, is due to a retained drainage-tube. Apart from faulty technique at the primary operation, this occurs when the amputation has been carried out for an infected condition of the extremity. The primary wound may not have healed in its entire length, and a small discharge occurs at one corner, particularly at the angle through which the drainage-tube emerged. If silk or thread has been used for ligature

of the vessels, it is best to wait in the hope that the ligature will discharge itself. If after two months the sinus is unhealed, a skiagram should be taken of the stump. A sequestrum is likely to be a small piece of bone, or a complete ring with spikes of bone proximally, which is separating from the shaft. A sequestrum should be removed as soon as the X-ray appearance suggests that it is free from the shaft. It is preferable to avoid cutting bone away, as further infection may occur (fig. 2310). It is inadvisable to close the wound completely, and it should be cleansed with spirit, packed with flavine and paraffin, and dressed weekly. If there is *osteomyelitis of the shaft* for some distance up the bone, re-amputation may be advisable above the infected area; this usually means above the proximal joint. In the case of the femur every effort should be made to preserve this, and an operation carried out on the lines of one for chronic osteomyelitis through an incision on the lateral aspect of the limb may be required and prove satisfactory.

A *granulating stump* is considered subsequently (see page 4277).

AMPUTATION IN THE PRESENCE OF SEPSIS

This is usually performed as a life-saving measure, when the surgeon's primary thought is the patient's life, with the realisation that a perfect stump may not be obtained from the primary amputation. It is practised most frequently in cases of infection superimposed on moist gangrene of the foot, gas gangrene, gunshot wounds, and severe infection of the tendon sheaths of the palm.

It must be realised that the tissues at any level of the limb are likely to be infected, although this may be indicated only by œdema, particularly around the vessels and in the subcutaneous tissue. Amputations through large joints should be avoided; Syme's amputation and those through the tarsus and metatarsus should not be carried out in the presence of sepsis.

As a life-saving measure the most simple operation to perform through the thigh or arm is that popularly called the "*guillotine*" *amputation* (see fig. 2311). A tourniquet is used, and the skin, muscle, and bone are divided in turn at the same level. The blood-vessels and nerves are dealt with as in any amputation. The large open wound is covered with a dressing soaked in flavine-paraffin emulsion.

This method can be modified by the use of *flaps*, and such is the operation of choice. The flaps should be cut so that the extensor surface flap is twice as long as that from the flexor surface. The muscles are divided and, without unduly disturbing them after division, the bone is divided about 1 inch above the level to which they retract. The vessels

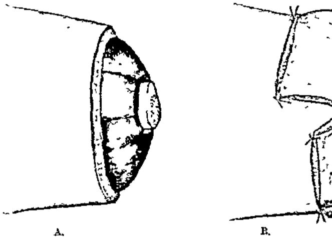

Fig 2311.—A. Appearance of stump after "guillotine" amputation. B. Appearance of stump after modified "guillotine" amputation with flaps stitched back.

and nerves are dealt with, and the skin flaps are sutured back to the skin above by a stitch at each corner. This leaves the muscles and possibly bone exposed. A flavine-paraffin dressing is placed over the exposed area. After seventy-two hours, if the patient's condition is satisfactory and the stump looks clean, the stitches are cut and the skin flaps are allowed to fall over the granulating muscle, but are not stitched. They will often cover it completely, as œdema of the muscle and subcutaneous tissue will have subsided.

If infection is present, the skin flaps are not unstitched for a week or so. After this time, whether the stump is clean or not, it is unlikely that they will cover the stump, but the dressings will be less painful and the healing time shorter than with the "guillotine" method.

Should it appear that the stump is unlikely to become a serviceable one when the patient's general condition has improved, two lines of treatment are possible:

(1) To apply extensions of strapping to the skin of the stump in order to draw this down. The other end of the extensions can be applied

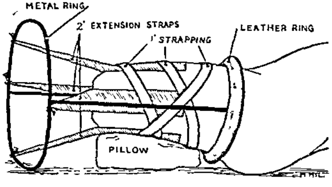

Fig. 2312.—Apparatus used to apply extension to skin in cases of skin retraction after amputation, such as may follow the "guillotine" operation.

to a ring as in figure 2312. This is always necessary in the "guillotine" operation; or

(2) To re-amputate the granulating stump. It is advisable to allow it to granulate until the unhealed area is the size of a large watch. If sequestration of the end of the bone occurs, this should be dealt with prior to the re-amputation. *As a preparation for secondary operation*, the area should be thoroughly cleansed, all scabs removed, and the surface painted with iodine twice a day for three successive days. Re-amputation must be carried out as far from the granulating area as the length of stump permits, and the technique must be planned so that the granulating area is not touched by instruments in the course of operation.

CONTRACTURES AND VASOMOTOR DISTURBANCES

It is recognised that subsequent to amputation a number of patients get a painful stump with contracture of the proximal joint. Often the *stump is cyanosed in colour and tender to touch, and the patient keeps* it wrapped up in layers of wool and bandages. Such a stump is seen at times when amputation is carried out for causalgia, and at other times for no reason which can be ascertained; the condition is most distressing to the patient, and the surgeon often proceeds from one operation to another without producing any relief. The primary treatment of causalgia is one of great difficulty, and in the other group of cases our knowledge of the ætiology is so deficient that no one can foretell whether any measure will produce relief. The efforts at relief that have been carried out include nerve injection, operations on the sympathetic nervous system and spinal cord, and re-amputation. The last is often *followed by removal of a further portion of the limb.*

The Lower Extremity

AMPUTATIONS OF THE TOES

(1) The *terminal phalanx* is amputated in cases of deformity of a toe with a painful corn or nail. A plantar flap is used with a transverse dorsal incision directly above the nail. The plantar flap is dissected back, and after the terminal phalanx has been removed the flaps are sutured in position.

(2) *Partial amputation of toes* through phalanges or the proximal interphalangeal joint is undesirable.

(3) *Amputation of an entire toe*, i.e. through the metatarso-phalangeal joint, is often required. The racket incision, that is, using lateral flaps, is the most satisfactory. In the 2nd, 3rd and 4th toes, the handle of the

racket lies in the middle of the dorsum of the toe, the uppermost point being above the metatarso-phalangeal joint. The flaps pass round the toe just distal to the web (fig. 2313). The incision is carried down to the bone; the two dorsal and plantar arteries are secured in the flaps; the plantar ligament is divided against the base of the first phalanx; the phalanx is enucleated; and soft structures not already divided are cut through. The incision for amputation of the 5th toe is indicated in the diagram. Amputation of the 4th and 5th toes leaves a strong foot, but amputation of the 2nd and 3rd toes is followed by hallux valgus and is often unsatisfactory. When any three toes have to be

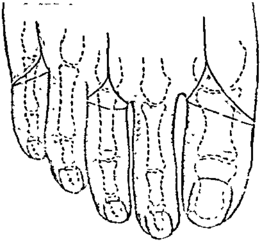

Fig. 2313.—Lines of skin incision for amputations at the metatarso-phalangeal joints. Note the flaps for the hallux and little toe.

removed, it is usually advisable to amputate all the toes including the hallux at the metatarso-phalangeal joints, and to remove the head of the 5th metatarsal.

(4) *Amputation of the hallux* (*big toe*): (*a*) The amputation through the interphalangeal joint is carried out as in the case of the other toes, but it is usually easier to open the joint from the dorsum and to carry the knife along the plantar aspect of the phalanx, i.e. to cut the flaps from within outwards.

(*b*) Racket incision is used for the amputation through the metatarso-phalangeal joint, but the handle of the racket is placed on the outer (little toe) side of the metatarsal bone. The flaps should be cut unequal, the larger one being along the inner side of the toe. This is done to prevent the scar being exposed to pressure from the shoe. Care must be taken that there is no tension over the metatarsal head. A modification of this operation is to cut through the 1st phalanx just distal to its base and to leave this attached to the metatarsal, thereby producing a better stump.

AMPUTATIONS THROUGH THE FOOT

These are seldom satisfactory. The standard amputations are:

(1) *Through the metatarsus* at any level.

(2) *Lisfranc's amputation,* and its modifications by Hey and Skey. The more of the foot that can be left the better, as a padded boot will be more comfortable and serviceable. The advantages of a flap from the sole are that the tissues on the sole are thicker and more vascular, and that the scar will be placed on the dorsum. These operations are not suitable if there is an equinus deformity which cannot be corrected.

(3) *Chopart's mid-tarsal amputation,* which consists in disarticulation of the foot through the astragalo-scaphoid and calcaneo-cuboid joints, so that the astragalus and os calcis remain on the limb. A long plantar flap is used. The operation is performed on the Continent and in Scotland, but it is not regarded with favour in England, owing to the equinovarus deformity of the stump which frequently follows. Fixation of the peronei and extensor muscles to the outer side of the astragalus and os calcis can be employed in an attempt to prevent this.

AMPUTATION AT THE ANKLE JOINT

Syme's amputation consists in using the heel as a covering to the lower end of the tibia and fibula, just above the ankle joint. It should not be employed if there is scar tissue in the skin of the heel, or in the presence of any gross infection in the foot. The details of the classical operation, originally described nearly one hundred years ago, have been somewhat modified, as the flap was found to be too large.

A sand-bag is placed under the leg, and the lower third of the leg protrudes over the end of the table. The operator stands at the end of the table facing the sole of the foot.

(1) *Skin flap.* The incision is elliptical, extending from above the ankle joint in front to 1 inch in front of the point of the heel. For the *right* foot, the incision begins on the outer side of the heel 1 inch in front of the point of the heel and is carried upwards over the tip of the external malleolus forwards and upwards to 1 inch above the ankle joint. It then passes downwards, crossing a point ½-inch below and in front of the tip of the internal malleolus to the side of the heel 1 inch in front of the point of the heel. A transverse incision across the heel joins the two ends of the incision (see fig. 2314).

For the *left* foot, the incision is commenced on the inner side of the heel, 1 inch in front of the point of the heel, and is carried round in the

reverse direction. The knife should penetrate right down to the bone all round the incision.

(2) *Disarticulation.* The foot is plantar flexed by the assistant, and a strong scalpel is used to divide in turn the anterior ligament of the

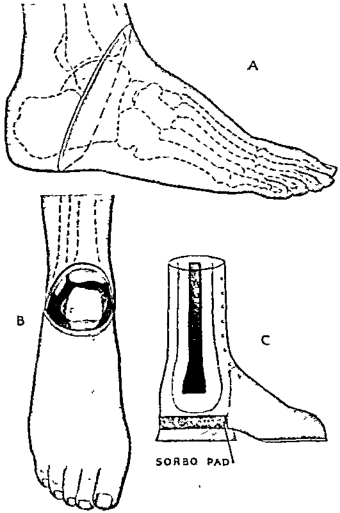

Fig. 2314.—Modified Syme's amputation.

A. The skin incision.
B. The ankle joint open in front.
C. Diagrammatic section of a suitable boot, showing the stump in the boot.

ankle joint, the lateral ligaments (from within outwards), and the posterior ligaments.

(3) *Dissection of the os calcis.* The foot must be kept plantar flexed while the surgeon dissects the tendo Achillis and heel pad of fat from the os calcis. The knife must be kept close to the bone during this procedure, the dissection being carried out by a series of incisions on to the bone.

(4) *Removal of the lower ends of the tibia and fibula.* The skin flap is retracted, and an incision made through the periosteum ½-inch above the level of the ankle joint and at right angles to the long axis of the leg.

The periosteum is gently pushed up with a broad fan-shaped elevator. The tibia and fibula are then sawn across not less than ½-inch above the joint, care being taken that the line of the division of bone is at right angles to the shaft of the tibia.

(5) *Soft structures.* The anterior tibial vessels and the internal saphenous vein require ligation, and the anterior tibial and musculo-cutaneous nerves, although small, should be picked up, drawn down, crushed and ligated. The plantar vessels are ligated, and the nerves dissected from the flap. The latter should be dissected up to the posterior tibial nerve, which is of considerable size. The nerve is crushed and ligated as far up as possible above the level of bone division. Other small vessels may require ligatures. Any tendons which have not retracted are drawn down and divided.

(6) *Closure of the wound and drainage.* The stump is bathed with saline at 120° F. and the flap sutured, care being taken that the mid-point of the heel flap is sutured to the mid-point in front. A small drain is inserted into each corner of the incision for two days. A drainage-tube should not be placed through a puncture wound in the heel flap.

This amputation produces an end-bearing stump, on which the patient can walk in six weeks. The simplest appliance worn is an "elephant boot," i.e. a boot with a strong broad heel, the leg piece of which is laced up the front like a long lace-up riding boot. This is usually more satisfactory than the more expensive and elaborate appliance which has a platform and side steels and an ankle movement device with rubber buffers below.

AMPUTATIONS THROUGH THE LEG

The standard operation provides a 7-inch stump of tibia, and is an excellent amputation when there is full movement at the knee joint. If only 5 inches of tibia are available, the function is nearly as good. With 4 inches of tibia the patient can manage an artificial limb, if his thigh and stump are not very large. When less than that is available, an above-knee amputation is advisable, unless he is to use a peg-leg with a flexed knee. By means of the latter, weight-bearing is taken on the anterior surface of the stump, which is flexed to a right angle. Such an appliance was provided when amputation at the site of election was practised. Amputation in the lower third of the leg is undesirable as the scar and flaps are liable to congestion and ulceration.

Mid-leg amputation. (1) The *skin incision* consists of a large anterior and a short posterior flap (or of a large anterior flap only, equal

in length to the diameter of the leg at the level of bone section). A length of tibia, 7 inches long from the knee joint, is measured and the point noted. The diameter of the leg at this level is measured, and a large anterior flap cut, measuring in length three-quarters of the diameter and in width half the circumference of the limb, so that the lateral incisions are just behind vertical lines drawn upwards from the malleoli. The transverse incision over the calf joins the upper third of the anterior skin flap (fig. 2315); this should be carried down to the

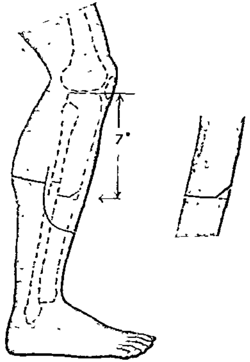

Fig. 2315.—Mid-leg amputation. The skin flap is marked out and the lines of division of the tibia and fibula are indicated.

bones. The flaps are cut so that the corners are rounded, and are reflected.

(2) The *muscles* in the front of the leg and interosseous membrane are divided. The periosteum of the tibia is divided and pushed up for half an inch.

(3) The saw is applied obliquely to the tibia one-third of an inch above the level at which it is intended to divide the bone. When it has been cut half through, the saw is removed and a transverse cut made across the tibia, the wedge-shaped piece of bone falling out, so that the line of division of the tibia is an obtuse angle. The fibula is then divided 1 inch above the level at which the tibia was divided. This can be done by a strong pair of bone-cutting forceps of the laminectomy type, care being taken that the bone is not splintered.

(4) The *vessels* are ligated, including the saphenous veins. Some

small vessels in the calf muscles require attention. It is very important to deal efficiently with the anterior and posterior tibial and the musculo-cutaneous nerves.

(5) The *flaps* are sutured, and should fit neatly. If they have been cut too long, so that they are loose over the ends of the bone, one flap should be shortened. A drainage-tube should be inserted across the stump. The scar will be placed *on the posterior aspect of the limb.* The knee joint should be kept extended during the convalescence.

The use of lateral flaps, producing a scar which is intended to be between the two bones, is less satisfactory than the method just described. It is possible to suture a portion of gastrocnemius over the tibia, but this is unnecessary.

Artificial Limb. The bucket consists of willow wood, duralumin, or leather reinforced by steel strips. Some makers insert a lining leather case which takes a bearing on the top of the bucket, to prevent the stump, especially if short, from slipping out. Pressure is taken by the head of the tibia and slightly by the lower border of the patella (fig. 2316).

The bucket is joined to a leather thigh corset and shoulder braces. A popliteal check cord or accumulator is fitted to prevent hyperextension of the knee. A jointed mechanism is used at the knee joint

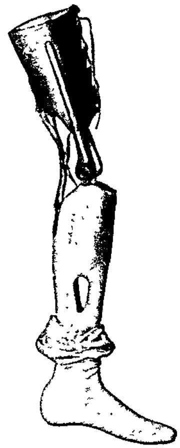

Fig. 2316.—Artificial limb used for leg amputations. The thigh control bucket is of moulded leather. (*Beckett and Bird.*)

AMPUTATIONS IN THE REGION OF THE KNEE

The three operations which are classical are termed: (1) Disarticulation of the knee joint (often called Stephen Smith's); (2) Stokes-Gritti's amputation; and (3) Carden's method. They were all designed to produce a weight-bearing stump. Artificial limbs made at the present time cannot be fitted to these stumps satisfactorily, and the patient profits by a shorter stump with weight-bearing on the tuber ischii. *The operations are rarely carried out, either in this country or in France* and Germany. A report compiled from statistics from the latter two countries shows that there were 17 disarticulations at the knee joint to 507 amputations of the thigh. In this country probably still fewer disarticulations would be recorded. The disarticulation will be chosen

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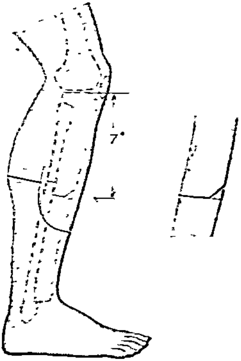

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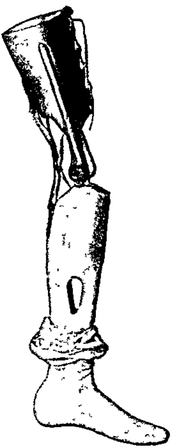

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(*Beckett and Bird*)

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by a few surgeons in feeble elderly subjects, as a life-saving measure in cases of gangrene, *in some cases of gunshot wound of the leg as a* primary operation, and in a few patients who, owing to congenital abnormality or previous injury, have been accustomed to weight-bearing on a flexed knee.

AMPUTATION THROUGH THE THIGH

The operation of choice is by an anterior flap with division of the femour $2\frac{1}{2}$ inches above the level of the knee joint (fig. 2317). It is frequently employed in cases of injury, gangrene of the foot and leg, tuberculous disease of the knee joint, and sarcoma of the leg.

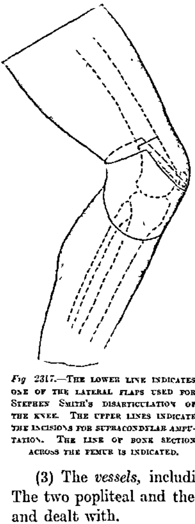


Fig 2317.—THE LOWER LINE INDICATES ONE OF THE LATERAL FLAPS USED FOR STEPHEN SMITH'S DISARTICULATION OF THE KNEE. THE UPPER LINES INDICATE THE INCISIONS FOR SUPRACONDYLAR AMPUTATION. THE LINE OF BONE SECTION ACROSS THE FEMUR IS INDICATED.

(1) *The skin flap* is equal in width to the diameter, and in length to two-thirds of the diameter of the limb (see fig. 2317). This is quite sufficient as the skin stretches easily in this region. This flap is reflected, and the rectus tendon and quadriceps muscle are divided above the patella and similarly reflected. The posterior incision is then made transversely across the popliteal space, joining the two ends of the base of the flap. The hamstring muscles are divided in the same line. The remaining muscles, vessels and nerves are picked up with artery forceps and divided.

(2) A muscle retractor is placed over the muscle. The periosteum is cut cleanly and pressed upwards, and the femur is sawn through, $2\frac{1}{2}$ inches above the knee joint.

(3) The *vessels*, including the internal saphenous vein, are ligated. The two popliteal and the long saphenous nerves should be identified and dealt with.

(4) *The hamstring muscles* are now sutured to the quadriceps, the stitches passing through the muscular sheath as well as the muscle, so that a good covering for the bone is formed. Care should be taken that the bone is in the centre of the muscular tissue, which has a tendency to slide sideways.

The skin flap is sutured and a drainage-tube inserted. The scar will lie posteriorly.

Note 1. This amputation may be performed after circular, elliptical, equal or unequal lateral or antero-posterior skin flaps.

Note 2. If this operation is performed for tuberculous disease of the knee joint, care must be taken to avoid infecting the wound. The suprapatellar pouch and any other infected area should be dissected out at as early a stage of the operation as possible, and clean instruments should then be employed.

Note 3. During convalescence this stump must not be allowed to become flexed at the hip joint.

Mid-thigh amputation. As much length of bone as possible should be preserved. If the foregoing amputation cannot be carried out,

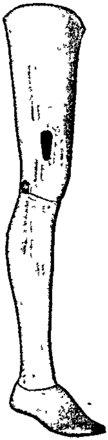


Fig. 2318.—Artificial limb used after thigh amputations. The "accumulator elastic" mechanism for knee joint control is within the limb. The straps for fixation to the trunk are not shown.

(*Beckett and Bird.*)

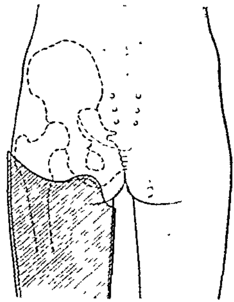


Fig 2319.—Bucket of artificial limb fitting the ischial tuberosity (seen from behind).

a useful stump can be obtained with the bone divided at a higher level. Muscle retraction hardly ever occurs in amputation above the middle of the thigh. Preventive treatment of spurs is advisable (see page 4273).

Artificial appliance. A pylon should be worn before the stump is ready for the permanent appliance, which consists of a bucket of wood or light metal, attached by side steels to the leg and foot-piece (fig. 2318). There are joints at the knee, which allow a definite range of movement, and here is an elastic or cord appliance to prevent hyperextension of the knee. The foot mechanism allows

a rocking movement and in most limbs allows movement at the level of the ankle joint and behind the toes The weight of the body is transmitted from the tuber ischii to a small rounded platform at the top of the bucket (see fig. 2319). It is essential for the patient to learn to sit on this platform.

DISARTICULATION OF THE HIP JOINT

This operation is employed in cases of tumours and extensive necrosis of the femur, and rarely in severe injuries of the thigh and in some cases of tuberculosis of the hip joint with secondary infection, also in the case of a limb completely flail from anterior poliomyelitis.

Although hæmorrhage and shock are reputed to be serious and immediate dangers, this should not be the case if the patient is prepared for the operation and if the technique for hæmostasis is efficient. If the patient is in a poor state of health, blood or saline transfusion should be employed prior to the operation, and vessels should be clamped before they are divided.

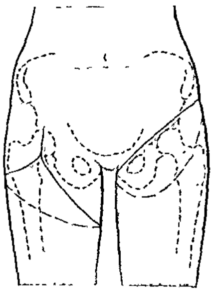


Fig 2320—On the right thigh is shown the racket incision employed for disarticulation at the hip joint. On the left, the posterior flap and anterior incision are depicted in the Fitzmaurice Kelly disarticulation.

The "stump" consists of the pelvis covered by skin and subcutaneous tissue, or, exceptionally, the head of the femur (or more) is left in the acetabulum. As the artificial appliance will not fit over a flabby mass of muscle and loose skin, redundant tissue should be trimmed away.

The operations usually employed are :

(1) *The anterior racket method*, which is the easier operation; and

(2) *Disarticulation by a posterior flap* (*Fitzmaurice Kelly*). For either operation the patient is seated on a sand-bag 3 inches deep at the end of the operating table, and the opposite limb is drawn away. The skin over the lower abdomen, pubes and perineum is included in the preparation for the operation.

Anterior racket method. This is suitable for amputation with division of the femur high up or for disarticulation.

(*a*) *Skin incision* (see fig. 2320—right thigh). The incision starts over the vessels at the level of Poupart's ligament and is carried down in the line of the vessels for 4 inches. It then passes obliquely round the inner side of the thigh, crossing the adductor muscles 4 inches

below the perineum. The femoral vessels are exposed, ligated separately, and divided between ligatures. The skin incision is then continued across the back of the thigh and over the great trochanter to join the original incision.

(*b*) *Muscles* on the front of the thigh are divided and the joint capsule opened in front. The other muscles are divided, vessels being clamped before division whenever possible. After division of the posterior part of the capsule, the limb is removed.

(*c*) The nerves are dealt with as described previously.

(*d*) Trimming of the flaps may be necessary; the wound is sutured and drained at the outer corner of the wound.

Posterior flap method. (*a*) *Skin incision* (see fig. 2320—left thigh). An incision is made obliquely across the front of the thigh, parallel to Poupart's ligament, from outside the anterior superior iliac spine inwards. The vessels and anterior crural nerve are isolated and divided between ligatures. A posterior flap is marked out, so that when brought forward the stump will be covered without tension. It is a semicircular flap, in length as great as the diameter of the top of the limb from before backwards. It is dissected up as far as the sciatic notch.

(*b*) The muscles are divided close to the pelvis, at first in front and then medially and laterally, leaving the posterior muscles until last, the vessels being clamped prior to division.

(*c*) The femur is disarticulated after division of the capsule.

(*d*) The flaps are trimmed so that the posterior flap fits snugly over the bony prominence, and the suture line is parallel to Poupart's ligament. The drainage-tube is placed at the inner end of the wound or 2 inches from this point.

Fig. 2321.—"Tilting table" artificial limb used after disarticulation of the hip joint.

(*Beckett and Ford.*)

Artificial limb. This consists of a "tilting table" limb fitting to the tuber ischii and to the outer surface of the pelvis (see fig. 2321). It should be made to fit *closely, both in the walking and the sitting positions.* This "tilting table" is fixed to a thigh piece, between which is a hinge which the patient can unlock when he sits down. The leg and foot are mainly similar to those in other lower limb appliances. Pelvic bands and shoulder braces are necessary.

HIND-QUARTER (INTERINNOMINO-ABDOMINAL) AMPUTATION

This operation is known to have been performed in seventy-nine cases with a mortality of 59 per cent. It has generally been performed for tumours of the innominate bone and the upper portion of the femur. Gordon-Taylor and Wiles state that "the important points in the conduct of the operation are: (1) The most gentle care in turning the patient; the danger from rough or excessive movement of the patient under spinal anæsthesia cannot be exaggerated. (2) The most thorough organisation of blood-transfusion arrangements. (3) Division of the posterior portion of the dorsum ilii with the saw is more expeditious and simple than disarticulation of the bone at the sacro-iliac synchondrosis; it is easy subsequently to oblate the auricular portion of the ilium. (4) It is necessary to stress the importance of minimising hæmorrhage and shock by preliminary control of vessels before division, and of nerve blocking before section of the trunks."

These writers' description of the operation should be carefully studied by anyone contemplating this colossal operation. (Gordon-Taylor and Wiles, *British Journal of Surgery*, 1935, XXII, 88.)

THE UPPER EXTREMITY

AMPUTATION OF THE FINGERS

This operation is usually required in cases of injury or subsequent *to infection.* The general rule is that amputation should be delayed as long as possible In considering removal of the fingers, it is useful to realise that the question of amputation arises: (*a*) Immediately after injury: (*b*) during the acute stage of infection in a finger; and (*c*) when the results of injury or infection remain.

(*a*) Immediately after injury, it often appears that laceration of skin, division of tendons, and fracture of phalanges are so extensive that a useful finger cannot be obtained. Immediate amputation just above the level of the proximal fracture will be the correct treatment if sufficient skin is available. This will be successful if the wound heals by primary union, as is likely if the operation is carried out within a few hours of the injury. If an attempt is made to save the part, infection may supervene, so that it may be difficult to decide when to amputate,

and this may have to be done at a higher level. However, if no surgical treatment, such as efficient cleansing of the part, is carried out for twenty-four hours, a primary amputation is likely to be followed by an infected stump. Consequently, if this delay has occurred, it is advisable to take all steps to prevent spread of infection and to amputate at a later date.

(*b*) It is unwise and rarely necessary to amputate a finger while a thecal whitlow is acute or when a sequestrum from a phalanx is present, surrounded by infected granulation tissue. In such cases, except when septicæmia has arisen, treatment should be directed towards saving the finger.

(*c*) This group comprises the end-results of groups *a* and *b*. The amputation is in the nature of a "set operation" and is carried out preferably when there is no sinus or unhealed scar. Amputation is recommended in these cases, owing to a portion or the whole of the finger being useless and often preventing other fingers from carrying out their full function.

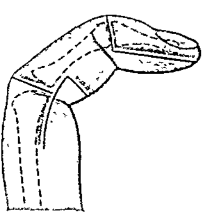


Fig. 2322.—Skin flaps employed in amputation through the terminal and first interphalangeal joint of a finger.

(1) *Amputation at the terminal phalanx.* The tip of the finger is held in the left hand and the terminal phalanx is fully flexed. With a small scalpel a transverse incision is made across the dorsum of the finger a quarter of an inch distal to the last bend of the finger (fig. 2322). This passes through skin and extensor tendon and enters the joint. The lateral ligaments are divided, and the scalpel is then turned so that the cutting edge is towards the end of the finger. The incision is then carried on to make sufficient palmar flap, and the amputated portion is removed. The palmar flap is stitched back so that the scar is on the dorsum. The bleeding will generally cease without the application of any ligatures.

(2) *Amputation through the second or first phalanx,* or at the first interphalangeal joint, is carried out by a palmar or equal lateral flaps. Amputation through the proximal end of the second phalanx is not advisable. The digital vessels require ligation, and it is most important to search for the digital nerves, pull them down, and crush and ligate each in turn, as a small neurofibroma, particularly when attached to the scar, is likely to be painful. The skin flaps are the only covering necessary, suture of the tendons being of no functional value, since the first phalanx is flexed by the interossei muscles.

(3) *Disarticulation at the metacarpo-phalangeal joint.* Whatever skin flaps are cut, these should be sufficiently large to allow full range of abduction of the neighbouring fingers. Although flaps can be formed from any surface, the surgeon should aim at avoiding any scar on the palmar aspect. The *middle* and *ring* fingers are most easily removed by a racket incision. This is marked out first (fig. 2323). The extensor tendon is divided and the joint opened on the dorsum. The knife is kept close to the bone whilst separating the phalanx from the metacarpal head, and the palmar structures are divided. The digital vessels and nerves are then picked up and dealt with.

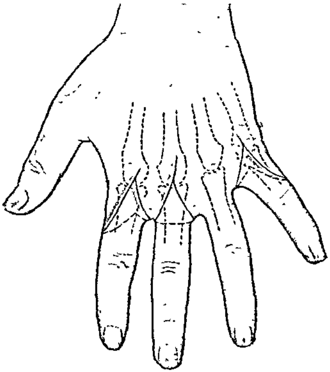


Fig. 2323.—Lines of skin incision used for amputation of little, middle and index fingers. Note the lateral flaps used for index and little fingers.

The flaps for the *index* and *little* fingers should be cut so that the scar is protected This is carried out in the case of the index finger by using a flap cut from the thumb side, and the incision on the other side of the finger extends right down to the web (see fig. 2323). For the little finger the larger flap is cut from the ulnar aspect of the finger.

Discussion arises concerning the advisability of removing the head of the metacarpal bone, instead of disarticulating through the metacarpo-phalangeal joint. A stronger hand remains if the metacarpal head is left in place, and a glove with dummy finger fits better. If the head of the metacarpal bone of the ring or middle finger is removed, the appearance of the hand is less unsightly, as the fingers will fall

together, but strength of the hand will be sacrificed for the sake of this improved appearance. The appearance of the stumps of the index and little fingers will be improved by cutting off the part of the head obliquely, and this weakens the hand less than complete removal of the head. The radial half is removed obliquely in the index finger and the ulnar half in the little finger.

(4) *Amputation of a finger with the metacarpal bone.* This operation is seldom required, except in cases of injury to bone and tendons, when the amputation is usually not limited to one digit. The surgeon has to use his discretion as to the level of amputation, possibly through two or more metacarpal bones. This is the type of case when delay in the amputation is desirable if possible.

The amputation is often carried out as a practical exercise.

An incision is made over the whole length of the metacarpal bone and carried round the base of the finger just distal to the web. The periosteum of the bone is incised and the bone cut through its shaft just distal to the base. The bone is thereby removed subperiosteally, so that there is no interference with the muscular attachments.

AMPUTATION OF THE THUMB

This is required in cases of injury and, rarely, of disease. It is not carried out as a set operation, for any operative procedure is performed with the object of preserving all possible tissue. Stiffness of the joint is so small an incapacity compared with the loss of any tissue of the thumb that it need hardly be considered if the surgeon contemplates amputating a portion of the thumb. When the thumb has to be trimmed after injury, an attempt should be made to make scars on the dorsum. If there is not sufficient skin to cover the injured area, this is no indication to amputate, as the area can be grafted with skin at a later date. When it is necessary to remove bone, this should be done subperiosteally. If the attachments of the short thumb muscles are injured, these should be sutured to the neck of the metacarpal, or if the terminal phalanx has to be removed, they should be fixed over the head of the metacarpal bone.

DISARTICULATION AT THE WRIST JOINT

This operation is rarely employed, for injuries of the hand either enable the surgeon to preserve a portion of the hand, or else injure the wrist as well so that amputation at a higher level is necessary. It is seldom called for in tuberculous or septic disease or in tumours of the hand. The advantage of disarticulation at the wrist over amputation at a higher level is that pronation and supination are still possible.

(1) *Skin incision.* The choice lies between a palmar flap and a circular incision 1 to $1\frac{1}{2}$ inches below the styloid process of the radius. In injury the flaps may have to be cut in an irregular way owing to skin laceration. The *palmar flap* consists of a rectangular flap with two rounded corners. It begins just below the styloid process of the radius and is carried over the ball of the thumb in the direction of the index finger. At the level of the outstretched thumb, the knife is carried across the palm at right angles. When it comes opposite the space between the ring and little fingers, it is carried upwards towards the styloid process of the ulna, stopping short of this by $\frac{1}{2}$-inch. This flap is dissected up so as to include the muscles of the thenar and hypothenar eminences, the palmaris longus, the terminal branches of the ulnar artery and nerve, and the pisiform bone if this is healthy. The posterior incision, which is carried across the dorsum of the wrist so as to join the base of the palmar flap, is made down to the bones.

(2) *Disarticulation.* The ligaments are divided on the dorsum and the carpus disarticulated from the radius and ulna.

(3) *Soft parts.* The flexor tendons are divided, as are also the anterior ligaments. The radial, ulnar and terminal branches of the interosseous arteries are ligated, and the median, ulnar and radial nerves are secured and dealt with. The styloid processes are cut flush with the articular surfaces of the radius and ulna. The tendons are further cut short if necessary, but some surgeons consider that better function is obtained by suturing flexor to extensor tendons over the ends of the bone. Drainage is advisable after skin suture.

AMPUTATION THROUGH THE FOREARM

This is required after severe injuries and for advanced tuberculosis or infection of the hand. The longer the stump, the better control will the patient have of the artificial appliance. Every effort should be made to perform the bone section below the insertion of the pronator radii teres, as ability to pronate and supinate is advantageous. If the amputation has to be done at a higher level, 3 inches of ulna are necessary in a forearm stump in order to control the bucket; for although the latter may sit well to a short stump with the elbow extended, it is too tight when the joint is flexed, owing to the bulk of the muscles in the front of the elbow on flexion.

The skin flaps often have to be fashioned from such skin as is available. As a terminal scar is as satisfactory as any, it is of little importance whether the skin is cut by the circular, antero-posterior or lateral method. The flaps should be short, as the skin stretches readily. To

carry out the amputation, the limb is abducted from the thumb and the forearm supinated. After reflection of the skin by one of the flap methods indicated, the muscles are divided transversely. The periosteum is divided neatly and pushed upwards prior to division of the radius, which is cut through first. The vessels and nerves are then dealt with. The muscles are sutured over the ends of the bone and between the two bones, because free stripping of the periosteum and this muscular strip between the bones should prevent bony ankylosis between the ends of the radius and ulna. This is the usual sequence if no effort is made to prevent it. Fusion of the bones abolishes pronation and supination.

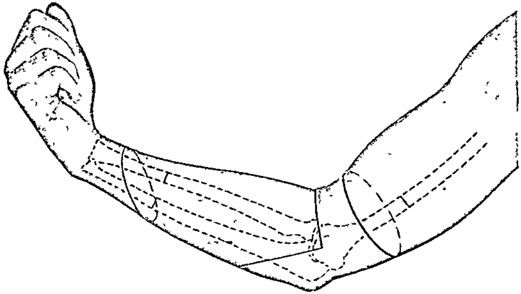


Fig 2324.—The line nearest the wrist shows the elliptical incision for low forearm amputation and the line of bone section. The flaps at the elbow are those used for disarticulation. The circular incision is shown for amputation of the lower third of the arm, with the line of bone section.

DISARTICULATION AT THE ELBOW JOINT

This operation is not often performed, because in most cases, when it is indicated, sufficient skin is not available, and amputation through the lower part of the arm is chosen instead. It is indicated in extensive injuries of the forearm, when the upper three inches of the ulna cannot be preserved, or when there is insufficient skin available to cover that length of radius and ulna. It is inadvisable to employ disarticulation of the elbow for malignant growths in any part of the forearm because the whole length of the forearm muscles should be removed, and this necessitates amputation above their origin from the humerus. The shape of the stump produced after disarticulation is broad from side to side and flat from before backwards, owing to the shape of the lower end of the humerus. At first sight this odd shape appears difficult to fit with an artificial appliance, but it is found that it has a considerable

advantage over the round stump of low arm amputations in that prominence of the condyles prevents rotation of the artificial limb on the stump.

(1) *Skin flaps.* These depend on the skin available, and the surgeon should aim at making use of one of the three recognised methods of cutting flaps. The limb should be extended and supinated when the skin is marked out.

(*a*) *Circular*, in which the skin flap runs slightly obliquely, being three finger-breadths below the joint line on the radial side, and two on the ulnar. When cut in the circular manner, the skin will retract more on the radial side.

(*b*) *Elliptical*, in which the anterior part of the ellipse corresponds to the fold in front of the elbow, while posteriorly it crosses the ulna a hand's breadth below the joint.

(*c*) *By flaps, preferably a posterior flap.* This consists of a semicircular flap from epicondyle to epicondyle, the length of flap as measured from the tip of the olecranon being equal to the antero-posterior diameter of the upper end of the forearm. It is cut with the elbow flexed to a right angle. The anterior incision joins the epicondyle across the fold of the elbow, and is made with the arm extended (see fig. 2324).

(2) *Soft tissues* are divided down to the joint across the front of the elbow.

(3) *The disarticulation* is begun on the outer side, by dividing the ligaments and entering the joint between the capitellum and the head of the radius. When the coronoid process of the ulna is free from the humerus, the forearm is hyperextended and the posterior ligaments and attachment of the triceps are divided from the front.

(4) *Vessels and nerves.* Superficial veins, and the brachial, terminal branches of the superior and inferior profunda, and anastomotic arteries require ligation. The median, ulnar and musculo-spiral nerves require shortening, crushing and ligation. The musculo-cutaneous and internal cutaneous nerves should be dissected out and dealt with in a similar manner.

Drainage of the wound is advisable.

AMPUTATION THROUGH THE ARM

This amputation is easier to perform than many, as there is one bone in the centre and muscles are arranged compactly around it. It is indicated in cases of severe injury, neoplasm, and septic and tuberculous arthritis of the elbow joint.

The longer the stump, the greater the control of the artificial limb. A stump at the level of the axillary fold cannot control an appliance. Owing to the elasticity of the skin, this will pull down readily, and $4\frac{1}{2}$ inches of humerus, with the end covered with skin only, is of much greater value than 3 inches well covered with muscle and skin. It is usually possible to cover the end of the bone when this is divided at the same level as the skin.

The limb is abducted to a right angle. For amputations in the lower third of the arm a tourniquet is applied; above that level, an assistant can compress the subclavian artery, but the method of choice is to dissect out the large veins when cutting the skin flaps and then to expose the brachial artery and ligate it, the other vessels being picked up as they are exposed. Alternatively, all the soft tissues are divided quickly with one incision and the vessels immediately picked up.

The method of cutting the skin is usually circular, but flaps or an ellipse are equally suitable.

Artificial Hands and Arms

After amputations of the hand, an artificial hand made of wood or leather is used, covered with a glove. The appearance of this is usually the first thought of the patient, but he should be encouraged to use various appliances which can be fixed to the end of the bucket in place of the hand. A knife, fork, hook and tools are of greater value than articulated fingers. After amputations at a higher level, a corset is fitted to the upper arm, and a hinge is placed at the elbow if the patient can control this joint, or an artificial locking elbow after amputation at the joint or above. A metal or leather forearm bucket is used for the forearm. A shoulder cap and chest belt extending round the opposite axilla are necessary in amputation above the elbow. Careful arrangement of straps from the shoulder cap to the arm bucket or corset aids the movement at the shoulder.

DISARTICULATION AT THE SHOULDER JOINT

This operation is seldom required except for severe injuries of the arm when the upper end of the humerus is fragmented. In malignant disease of the humerus, it may be employed if the intention of the surgeon is to rid the patient of a growth which has ulcerated, or is about to do so, through the skin. The forequarter amputation is likely to be the operation of choice in sarcoma of the humerus, but this may be contra-indicated by the patient's general condition. Disarticulation at the shoulder may be modified by dividing the humerus at the anatomical neck and leaving the head in the glenoid, thus preventing the extreme flattening of the shoulder.

The operation of choice is a modification of Spence's, which enables

the operator to limit the hæmorrhage. The arm is abducted 45 degrees from the trunk and externally rotated.

(1) *Skin flap.* The coracoid process is located and the incision made from this point downwards in the long axis of the arm to the lower border of the anterior axillary fold. It then passes outwards over the deltoid and round the arm to the posterior axillary fold. It is continued forwards and upwards to join the vertical incision (fig. 2325).

The flap on the inner side is dissected up, and the pectoralis major divided. In cases of injury, this is cut close to the humerus, but in malignant disease, as far away as possible.

(2) *Vessels and nerves.* The axillary artery and vein are clamped at the level of the shoulder joint and divided between ligatures. The nerves of the brachial plexus are clamped, pulled down, reclamped, and ligated before division.

(3) *Disarticulation.* The external flap is dissected up and retracted with the greater part of the deltoid muscle adherent to the flap, except in cases of malignant disease.

Both heads of the biceps are divided and the joint opened in front. The knife is then applied to the humerus, so as to divide the muscles attached to the tuberosities and neck. The posterior portion of the capsule is divided and the limb is removed. A number of bleeding points will then require attention. The wound is closed and drained.

Note The tendency is to cut the flaps too long, so that the axillary scar is redundant and the folds of skin tend to cause trouble. Hence, if there appears to be excess of skin, this should be trimmed before closing the wound.

FOREQUARTER (INTERSCAPULO-THORACIC) AMPUTATION

This extensive operation (fig. 2325) is usually performed in cases of sarcoma of the upper end of the humerus, whether the shoulder joint is involved or not. It is rarely used for injury, acute gangrene, or infective conditions of the upper limb. The amputation is usually carried out as originally described by Berger in 1887. This involves the removal of the upper limb, scapula, and part of the clavicle, with division of the muscles close to the latter two bones. Pre-operative transfusion of blood may be advisable.

(1) *Position of the patient.* The patient lies on his back with the shoulder of the affected side overhanging the side of the table. A second assistant holds the upper limb. The position may be kept constant by placing a sand-bag under the unaffected shoulder.

(2) *Exposure of main vessels.* An incision is made commencing over the sterno-clavicular joint and extending along the upper border of the

inner two-thirds of the clavicle. The clavicle is cleared of muscle and periosteum, so that it can be divided, preferably with a Gigli or 2-inch bladed saw, at the junction of the middle and inner thirds. The outer portion of the bone is then drawn outwards and upwards and the subclavius muscle and fascia carefully divided so as to expose the subclavian vessels and brachial plexus. In order to have greater space some surgeons prefer to resect the middle third of the clavicle, dividing the bone at the inner point first and then stripping the posterior surface before dividing the junction of the middle and outer thirds.

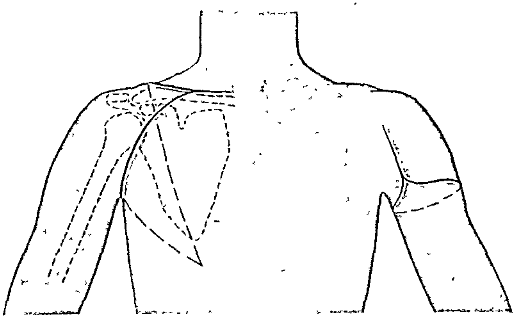


Fig. 2325.—On the left shoulder the skin incision for disarticulation at the shoulder joint is indicated. On the right shoulder is shown the skin incision for forequarter amputation.

(3) *Division of vessels and nerves.* Each trunk of the plexus is injected with 1 per cent novocaine, crushed just distal to the swelling caused by the injection, ligated, and divided with a sharp scalpel. The subclavian artery and vein are divided between ligatures at the level of the first rib. The suprascapular and posterior scapular arteries are ligated as they pass laterally in front of the scalene muscles.

(4) *The anterior dissection.* The arm is abducted almost to a right angle with the trunk. The outer end of the skin incision is continued by carrying it over the coracoid process downwards and outwards across the anterior axillary fold. It then passes backwards across the axilla and down the chest wall to the inferior angle of the scapula. This flap is dissected inwards. The pectoralis major is dissected up and divided close to the thorax, the vessels being picked up before division. The axilla and lateral chest wall are dissected downwards, stripping the

which might be ruptured. The majority of surgeons consider that in patients over the age of fifty a tourniquet should not be employed. When a tourniquet is used, the question will arise as to when it should be removed. The usual custom is to remove it as the dressing is being applied. Such dressing should include a considerable quantity of good quality wool and should be bandaged firmly. If the surgeon wishes to remove the tourniquet before closing the wound, it is essential that he should ligature a large number of small vessels before closing the wound and applying the dressing. The method of retaining the tourniquet until the dressing has been applied is more popular at the present time. Undoubtedly it is to the patient's advantage that there should be no hæmatoma either into a reconstructed joint or subcutaneously, particularly as a hæmatoma encourages infection and subsequent ankylosis; but post-operative hæmatoma will occur in a proportion of cases operated on under a tourniquet. These operations can be carried out with so much greater precision in a bloodless field that the tourniquet is advised, and every effort should be made to avoid post-operative hæmatoma, by picking up all vessels *before* division as the operation proceeds, by ligating them, and by firmly applying an adequate quantity of wool in the dressing, while the limb is held elevated. Injury to the nerves of the arm by a tourniquet is avoidable by the use of the pneumatic type of apparatus. The length of time that a tourniquet can be left in place is a constant worry to the operator. It is impossible to be dogmatic as to how long it is safe to keep pressure on the vessels and maintain a bloodless limb. Further, no general rule can be made on the matter. Obviously it is impossible to state that a tourniquet should be used for one operation and not for another, as the speed of each operator varies greatly. The removal of a tourniquet during an operation is most unsatisfactory as this usually causes displacement of towels, the liability of soiling the operation area, and a considerable flow of blood into the wound. Hence, if it is known that an operation will be a long one, it is better to start without a tourniquet; should an operation be started under a tourniquet and occupy a longer time than anticipated, it will be safer to remove the tourniquet, in spite of the disadvantages, than to risk the very serious consequences that may occur if this is not done.

The incision for the operation on any joint should be planned so that an adequate exposure of the joint can be obtained and so that it can be enlarged if necessary. It should be so placed as to afford ready exposure of the intermuscular planes or of the space between tendons. Obviously, vessels and nerves are to be avoided. If an incision has to

be made near the course of a nerve, it is advisable to expose the nerve along a sufficient length of its course to render it visible if necessary during the operation. When this has been carried out, the assistant is told that he must keep a constant watch on it and retract it with care, so as not to bruise it.

When the operation aims at fixation of a joint, the care of *muscles* and *tendons* is not of the same importance as when the object is to improve movement. In all operations, division of muscle is likely to cause bleeding and should therefore be avoided. Whenever possible the approach to the joint should be in intermuscular planes. When insufficient exposure of the joint is obtained by such a route, it may be necessary to separate the origin or insertion of muscles. It is usually advantageous to remove them from the bone with a thin osteotome, so that a thin flake of bone is left attached to the muscle or tendon (e.g. an epicondyle of the humerus). This facilitates reposition and injures the muscle less, so that the muscle functions sooner and more efficiently. The capsule of the joint should be opened in the long axis of the limb, and usually closely in front of or behind a lateral ligament. If it is necessary to remove *the attachment of the capsule completely from* one bone, this is best done with a broad periosteal elevator, after the joint has been opened (e.g. anterior attachment of the capsule of the elbow joint from the humerus). The capsule should not be divided transversely.

ARTHROTOMY

Arthrotomy, indicating the opening of a joint, is a term little used, although the operation is so frequently carried out. The name of the type of operation or of its purpose is more often employed.

The indications for arthrotomy are:

(1) In infective conditions: (*a*) for diagnostic purposes; and (*b*) for drainage.

(2) For removal of foreign and loose bodies from a joint.

(3) Following trauma: (*a*) fractures into joints; (*b*) unreduced dislocations and fracture-dislocations; and (*c*) mobilising a stiff joint.

(4) In disease of the articular cartilage and of the ends of bones.

The skin incision should be placed over the area where the capsule *of the joint is most superficial. Longitudinal incisions should* be employed. The incision should be as small as possible, as a scar in synovial membrane and capsule tends to prolonged effusion. In closing wounds of joints, accurate suture of synovial membrane, with the edges turned out, is advised. Drainage-tubes should not be placed in the joint. Firm bandaging over an ample quantity of wool is necessary.

EXCISION

The classic operation consists in opening a joint, resecting the articular ends of the bone, and removing the capsule and synovial membrane, this being followed by closure of the wound. In most cases the operation has been carried out to remove disease and provide a movable joint. A "text-book description" for excision of most joints of the body exists, but the operations so described are seldom suitable for clinical conditions, owing to the irregularity of the spread of the disease or to deformity from injury. Often removal of a part of a joint will produce an equally efficient result. Some excisions are followed by an ankylosis (e.g. of the knee) which is advantageous, whereas others produce flail joints. This type of operation is not considered at the present time suitable or necessary for tuberculous disease. In the case of post-traumatic lesions, types of arthroplasty now replace most of the formal excisions. Excision of the elbow joint is recognised as a useful operation. Excision should not be practised as an emergency operation after accidents involving joints.

ARTHRODESIS

Arthrodesis is an operation performed to produce fixation of a joint—that is, ankylosis. The latter may be fibrous or bony. Fibrous ankylosis is usually painful and the position of fixation liable to alter. Hence, any operation of the arthrodesis type should be planned to produce bony ankylosis and to put the joint in the best position for function.

There are two methods of performing arthrodesis which are called *intra-* and *extra-*articular arthrodesis; sometimes the two are combined. The first method consists in removal of joint tissue until two bony surfaces can be placed in apposition so that bony union will occur. In the simplest cases this will necessitate removing the articular cartilage from the ends of the bones; whereas in more complicated cases it may be advisable to remove synovial membrane, articular cartilage, and areas of diseased bone. Sometimes the bony surfaces will be kept in contact by the use of pegs of bone, screws or nails, or the inlay of a bone graft taken from another area of the body.

Extra-articular arthrodesis consists in the fixation of the joint by bone without opening the joint. It is carried out by the use of a bone graft obtained from the neighbourhood of the joint or from another part of the body. For instance, a graft from ilium or tibia may be employed to fix the hip joint, the graft uniting the great trochanter to

the ilium. Arthrodesis of a number of joints at the same time is employed in the foot for flail foot.

Joint fixation by fascial transplantation or transposition of tendons is seldom satisfactory; likewise, there are few advocates of such methods as the driving of pegs, pins or screws through the articular surfaces of two bones from without, as a means of producing ankylosis of the joint without exposing the joint.

The principal indications for arthrodesis are: (1) Cases of flail joint due to muscular paralysis or deficiency sufficient to limit a useful function of the joint; (2) certain cases of tuberculosis of joints; (3) cases of infective or toxic arthritis, including osteo-arthritis, particularly when the joint is quiescent and there is a fibrous and painful ankylosis; and (4) subsequent to trauma when a fracture or fracture-dislocation has produced a painful joint.

The indications for this operation are referred to in greater detail subsequently, when discussing particular joints.

Before considering the merits of intra- and extra-articular arthrodesis, it is advisable to stress the importance of a joint being ankylosed in what is popularly termed "*the best position.*" This is not only the position in which the joint is placed when it is arthrodesed by operation, but is the position which should be aimed at whenever the joint is treated. When treatment is being carried out for a joint lesion, of a type such as may lead to ankylosis, it is advisable to place the limb in such a position that, should ankylosis occur, the limb will be in the most useful position for function.

(*a*) *Shoulder joint;* in children—90 degrees abduction; in adults—75 degrees abduction. In both cases, the elbow should be 30 degrees in front of the body plane, i.e. a line drawn through the middle of the body from shoulder tip to shoulder tip.

(*b*) *Elbow joint;* the forearm should be flexed 90 degrees on the arm and midway between supination and pronation. On the rare occasions when both elbows are ankylosed, the most useful position is for the right to be flexed at about 100 degrees and the left at about 75 degrees.

(*c*) *Wrist joint;* dorsiflexed to 45 degrees.

(*d*) *Fingers;* the terminal interphalangeal joint at 150 degrees, i.e. 30 degrees from fully extended.

(*e*) *Hip joint;* flexion to not more than 30 degrees, abduction 20 degrees, and slight external rotation.

(*f*) *Knee joint;* fully extended with the foot square.

(*g*) *Ankle joint;* the foot should be placed at a right angle to the leg.

(*h*) *Foot;* when multiple arthrodeses are carried out, the foot should be displaced backwards below the astragalus.

(*i*) *Interphalangeal joints* of toes should be fixed extended or slightly flexed.

From the remarks on the indications for arthrodesis and from studying the suitable positions in which to fix joints, it will be realised that every arthrodesis is carried out to *fix the joint in a correct position.* Whereas some types of arthrodesis are performed to help to cure disease, or a painful condition of a joint, others aim at correcting deformity. These may be combined. It is essential to consider the merits of intra- and extra-articular arthrodesis and to judge when either is a suitable operation.

By *intra-articular arthrodesis,* it may be possible to eradicate all disease (tubercle of the knee joint); to remove the articular cartilage to ensure bony union (shoulder in muscular paralysis); to convert fibrous into bony ankylosis (ankle joint); and to correct deformity and eradicate articular changes (osteo-arthritis of the hip joint with deformity). Shortening of the limb follows this procedure; it will be no disadvantage in the upper limb, and usually not in the lower limb, except when carried out in children so as to interrupt the growth of the bone. In some joints it is impossible to eradicate all the disease while performing the operation, so that the disease is likely to continue, often more severely than before operation was undertaken. This applies particularly to the hip. Likewise, if intra-articular arthrodesis is carried out when the disease is thought to be quiescent but is in reality still active, a recrudescence is likely to occur and produce a worse condition than was already present. The severity of the operation on the hip, combined with the fact that bony union has not always been obtained, leads operators to employ other methods.

By *extra-articular arthrodesis* it is possible to fix without opening the affected joint. It is suitable in certain cases of tuberculosis either at the commencement of the disease or when it is quiescent (sacro-iliac joint and hip joint); it is equally suitable in cases of fibrous union when an intra-articular arthrodesis will prove an extensive operation, particularly when it is feared there might be a recrudescence of the infective process. One type of extra-articular arthrodesis necessitates opening the joint; for instance, in one operation on the hip joint the graft is laid directly along the upper surface of the neck of the femur; such an operation would be suitable for osteo-arthritis of the hip joint but not for tubercle. As a general rule, a bone graft is not placed through a joint unless the articular cartilage has been removed,

as the graft is liable to absorb in the joint space; but this operation is performed with success by a graft across the ankle joint through the fibula, astragalus and tibia, when it can be planned so that the graft never actually forms a bridge.

Extra-articular arthrodesis is eminently suitable for certain cases of tubercle, particularly when the graft is implanted well away from the disease. Experience has shown how successful grafting of the spine is in cases of disease of the vertebræ in adults. Surgeons are tending to employ it for the hip joint, but there is no unanimous opinion as to the right time at which it should be undertaken, particularly in the hip and sacro-iliac joints. Tubercle of the hip joint in children and adults usually destroys a good deal of tissue even when the best treatment is carried out by general methods and efficient local treatment. The majority of cases treated without operation have a fibrous union at the end of their treatment; this is painful at some time later in life, and the joint tends to get into a position of flexion and adduction. Consequently, the present tendency is to advise early extra-articular arthrodesis of the hip, so that extra-articular bony union is assured; as the result of the operation the disease tends to spread less and to heal more quickly, deformity is prevented, and bony union is obtained. If the operation is delayed until the disease is quiescent, deformity may have arisen and shortening have occurred; hence, arthrodesis may be considered necessary in order to produce a painless joint and deformity may have to be corrected as well by an osteotomy; two operations of this nature may not be advisable when there is any doubt as to whether the disease is active.

It is probably fair to state that: (1) Extra-articular arthrodesis of the hip in an early stage of the disease has many advocates; (2) an arthrodesis of the knee joint for tubercle in adults is the recognised procedure as soon as the condition is confirmed by biopsy; and (3) that some form of arthrodesis, preferably extra-articular, is advocated in all cases of joint tubercle when they are quiescent, provided no sinus exists.

ARTHROPLASTY

Arthroplasty is an operation designed to produce movement at a joint —in fact, an artificial pseudarthrosis. The *principles* of the operation consist of: (1) The removal of bone and soft tissue, if any, interposed between the original joint surfaces; and (2) the prevention of union between the opposing ends of the bones.

Success of the operation depends on: (1) The removal of the correct amount of bone and the shaping of the ends of the bone which will

take part in the new joint; (2) the separation of the ends of the bones and the employment of some method to prevent their union; (3) the efficiency of the muscles around the joint; and (4) careful after-treatment.

Details of technique.

(1) The bone. When bony ankylosis exists, it is essential to divide this and to reshape the ends of the bones. When fibrous union exists, not only must the ends of the bones be shaped, but the interposing soft tissue must be excised. The quantity of bone that should be removed is a matter of controversy and must depend on the type of joint which one wishes to make. The common error is the removal of too small a quantity of bone. In shaping the ends of the bones, both stability and function must be considered; for instance, in the case of the elbow, every effort should be made to fit the joint surfaces accurately, and only sufficient bone should be removed to give free motion. The olecranon and sigmoid fossa should be preserved, or, if that is not possible, a new olecranon must be made. In the case of the hip joint, the plastic work is carried out on the head of the femur rather than on the acetabulum; but in the knee, the femur and tibia are both shaped. In this joint, stability is essential for weight-bearing, and is most easily obtained by cutting the lower end of the femur into a V-shape with an angle of 120 degrees in the angle in the V.

(2) The prevention of bony union is carried out by extension on the limb after the operation, and by applying Horsley's wax to the raw bony surfaces, or by the interposition of a flap of soft tissue. Wax is little used in this country for this purpose, and there is a divergence of opinion as to the value of an interposed flap. At one time it was thought that such a flap should consist of two layers and have a pedicle. It has been proved that a pedicle to a flap is of no advantage and that a flap of one layer is certainly as efficient as a double one. The next question is whether the flap should consist of fascia or of fascia and fat. Fat probably absorbs quickly, but fascia will live after transplantation, although the edges may necrose. The free flap is usually taken from the outer side of the thigh. Some surgeons rely on separation of the joint surfaces alone and do not use the fascial flap. When the latter is used, it should cover one bone snugly and thoroughly and should be fixed in position by a few interrupted catgut sutures. This is a particularly suitable covering for the lower end of the humerus and the head of the femur.

(3) Muscles. Muscular efficiency of any joint requiring this operation is below normal because the muscles will not have been in action

while the joint has been ankylosed or had great limitation of movement; but if there has been no nerve paralysis and the muscles are of a reasonable shape and size, their efficiency will return with after-treatment.

(4) The *after-treatment* consists in keeping the part at rest with extension. The length of time this is necessary will depend on the joint: the larger the joint the longer it is kept in extension. If voluntary movement can be started two weeks after the operation, immobilisation should certainly be continued, although a small amount of movement and muscle re-education is carried out daily. The *increase in the movement must be determined by the functional development,* and no passive movements should be employed. The aim should be for the patient to be able to work hard at moving his elbow in three weeks and for him to be bearing weight on the knee in six weeks and on the hip in four, but full weight-bearing will not be possible for ten to twelve weeks, and in the latter two cases a caliper *will help the patient considerably. Sudden increase of movement should not be* looked for. If the ends of the bones have a mottled appearance in the skiagrams six or eight weeks after the operation, the bones are likely to be soft, and rapid progress must not be expected. This appearance is an indication to limit weight-bearing but to encourage muscle training and voluntary movement.

The operation of arthroplasty is suitable in certain joints under favourable circumstances when the ankylosis has resulted from: (1) Trauma causing injury to joint surfaces and periosteum, particularly after severe fractures and fracture-dislocations; (2) acute arthritis due to staphylococcus, streptococcus and gonococcus, when the infection has been localised to an arthritis and the erosion has not been deep; or (3) certain cases of chronic arthritis, such as osteo-arthritis of the hip joint.

Mobilisation of a joint is contra-indicated when: (1) It is known that the infective process is still active; (2) the ankylosis was due to tuberculosis, in which case the risk of "lighting up" old infection is well recognised and, although successful arthroplasty has been accomplished, the risk is great; (3) the soft tissues are bound down to the bones by extensive scar tissue; (4) muscular weakness around the joint is extreme; and (5) the shafts of the bones near the joints are scarred by old infection and are either sclerosed or greatly rarefied.

Arthroplasty in children is seldom required and should be employed *with great caution.*

The favourable circumstances for mobilisation of a joint are: (1) Age between twenty and forty; (2) status of the patient—one who will co-operate in post-operative treatment and is intelligent; (3) general fitness of the patient and complete freedom from local or toxic infection; and (4) absence of scar tissue, particularly involving muscles around the joint.

Success of arthroplasty is greatest in the elbow, hip joint, and jaw. These joints are suitable because the articulation can be remodelled so as to be stable. Experience is showing that the keen joint is moderately suitable. Finger joints are seldom good joints for arthroplasty, as the tendons around the joint are usually badly scarred. The shoulder seldom needs mobilising, and arthrodesis of the wrist in dorsiflexion is satisfying. Although arthroplasty of the ankle has been performed, it is not necessarily painless, wherefore arthrodesis is to be preferred.

Operations on Individual Joints

TEMPORO-MANDIBULAR JOINT

Operation on this joint is required in cases of: (1) "Clicking jaw" or other symptoms indicating a lesion of the intra-articular disc of fibro-cartilage; (2) arthritis; and (3) ankylosis. (See also page 5121.)

The operation for the first condition consists in the removal of the disc. When *arthritis is painful and causing limitation of movement, the* condyle can be removed. In cases of ankylosis the condyle can be resected or an arthroplastic operation can be carried out, a flap of fascia lata or of temporal muscle being sutured over the neck after removal of the condyle.

Esmarch's operation on the horizontal ramus is suitable when the fixation of the jaw is due to cicatrices of the soft parts.

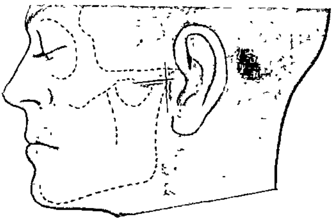


Fig. 2326.—Diagram showing the alternative incisions for exposure of the temporo-mandibular joint. The vertical incision is to be preferred, although the two may be combined.

Exposure of the joint. There is a choice of two incisions, either of which is probably efficient. The easiest incision is a vertical one in front of the ear parallel to the posterior border of the ascending ramus, which should extend from the upper border of the zygoma for a little more than one inch downwards. The alternative incision is along the lower border of the zygoma on a level with the tragus; the two incisions can be combined (fig. 2326). It is advisable to pick up the superficial

temporal vessels and to tie them, but branches of the facial nerve and the upper border of the parotid gland should be displaced downwards; the fibres of the masseter muscle are divided with a knife from the zygoma, and separated with a periosteal elevator. The capsule of the joint is then exposed and a vertical incision is made through it, exposing the neck of the mandible. If the operation is carried out to remove the fibro-cartilage, the incision is carried up through the capsule; this is drawn aside, and the cartilage is grasped in a pair of small artery forceps, drawn downwards, and separated from any attachment with a tenotomy knife. A stitch is put into the capsule, the masseter muscle replaced, and the wound closed.

When the operation of removal of the condyle is carried out, it is important to remove a considerable portion of bone, and the external pterygoid muscle must be separated from the neck. The neck is divided with a pair of small bone-cutting forceps. It will be known beforehand from the X-ray pictures whether the condyle is of normal shape or considerably destroyed. This information is very important as it is not easy to remove a deformed ankylosed condyle. If fascia is interposed, this must be stitched round the stump. Movement is commenced on the following day. If it should be necessary to do this operation on both condyles, a wedge should be kept between the teeth for two to three weeks and should only be removed for cleansing of the mouth, feeding, and movement. It is probable that little advantage is gained by using a fascial flap.

It is most important not to injure the parotid gland, or a parotid *fistula may form. A partial facial palsy occurs in a proportion of cases* but is only of a transient nature.

STERNO-CLAVICULAR JOINT

Operation on this joint is required in some cases of unreduced dislocation and of recurrent forward dislocation. As the joint comes into action when the arm is abducted beyond a right angle, fixation of the joint may impair the movements of the shoulder girdle. This is more likely to be the case if the joint is fixed owing to former infection (a rare condition) than in an unreduced dislocation. In either case it is probably advantageous to excise the inner end of the clavicle if the patient has a definite disability. In treating recurrent forward dislocation, the operator's ingenuity must come into play, as a buttress must be formed to prevent the clavicle from sliding forward.

ACROMIO-CLAVICULAR JOINT

The common injury to this joint is an upward dislocation of the clavicle. Such a condition may persist if the primary treatment has failed or if there have been repeated injuries. The superior acromio-clavicular ligament has usually been torn and the conoid and trapezoid ligaments stretched or detached. When considering operative treatment, it is important to determine whether the

disability is sufficient to warrant operative treatment. If the latter is undertaken, an effort should be made to reconstruct the parts rather than to fuse the clavicle to the acromion (fig. 2327). The operation will consist in exposing the acromio-clavicular joint and making new ligaments from fascia, probably fixing the clavicle to the acromion by a band of fascia passed horizontally through drill holes in both bones. In addition, it will often be necessary to replace the useless conoid and trapezoid ligaments by fascia passed round or through the clavicle to the coracoid process.

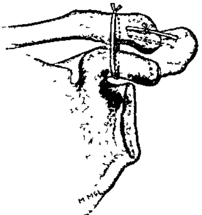


Fig 2327.—Diagrammatic representation of *fixation of clavicle to acromion and coracoid process by fascia lata or kangaroo tendon.*

SHOULDER JOINT

Arthrotomy. The opening of the shoulder joint is necessary in cases of: (1) Infective arthritis; (2) fracture-dislocations and some cases of unreduced dislocations; and (3) loose bodies in the joint.

The usual procedure is to open the joint from the front in cases of infective arthritis, and this is always done unless there is a definite swelling posteriorly. Counter-incisions posteriorly or at the apex of the axilla are sometimes necessary and helpful. If the latter is used, the arm must be drawn upwards above the head while the counter-incision is made. Although this incision provides good drainage, the dressing is not easy, and discharge over the axilla is liable to cause infection of the hair follicles. If the infection has arisen as a complication of osteomyelitis of the upper end of the shaft of the humerus, the bone should be approached from the postero-lateral aspect, and if drainage of the joint is considered necessary, this will be carried out through the posterior part of the capsule.

Arthrotomy by the anterior route is the method employed for the other conditions. A small sand-bag is placed behind the shoulder and the arm is slightly abducted. An incision is made from the lower border of the clavicle half-way between the coracoid and acromion processes, extending downwards in the line of the deltoid fibres. The deltoid muscle is split about 1 inch lateral to its inner border. There will be some hæmorrhage which is easily controlled. The muscle-fibres are retracted, exposing the bicipital groove if the arm is externally rotated.

Retraction of the upper part of the muscle will expose the joint. Some surgeons, however, prefer to retract the whole deltoid muscle without splitting it.

In the case of removal of *loose bodies,* the capsule will be split from above downwards and closed after removal of the bodies (fig. 2328).

In the case of *fracture-dislocation,* it will be necessary to decide if the head can be fixed on to the shaft and the dislocation reduced, or whether

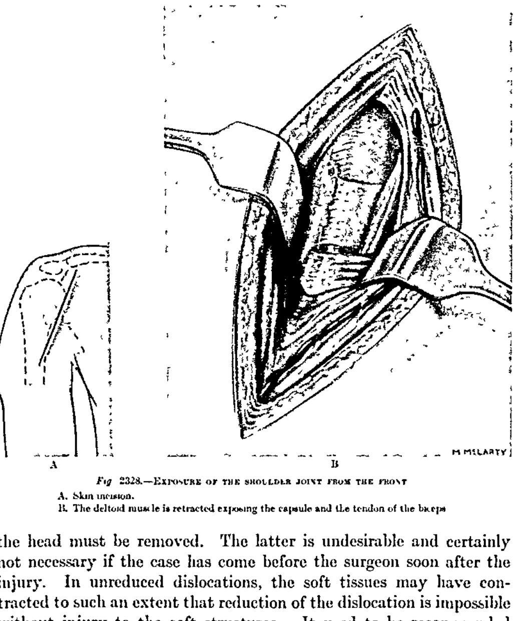


Fig 2328.—Exposure of the shoulder joint from the front

A. Skin incision.

B. The deltoid muscle is retracted exposing the capsule and the tendon of the biceps

the head must be removed. The latter is undesirable and certainly not necessary if the case has come before the surgeon soon after the injury. In unreduced dislocations, the soft tissues may have contracted to such an extent that reduction of the dislocation is impossible without injury to the soft structures. It used to be recommended that the head of the humerus should be excised, but a stronger arm will be obtained if reduction can be carried out, although full movements may not be obtained subsequently. After the operative procedure has

been carried out, the capsule is closed with interrupted stitches, the deltoid brought back, and the skin closed. After any one of these operations, the arm should be fixed in abduction prior to physical treatment which will consist of faradism to the deltoid, active movements. etc.

Arthrodesis. Indications: (1) Flail shoulder; (2) permanent deltoid paralysis; and (3) some cases of tuberculosis of the shoulder joint.

The operation for the first two conditions is intra-articular or combined intra- and extra-articular arthrodesis. Extra-articular arthrodesis is suitable for cases of tuberculosis, particularly when the inner portion of the head is mostly affected and tends to sink inwards. Whether this should be practised at the commencement of the disease or after general treatment and immobilisation has been carried out is a debatable point.

Intra-articular Arthrodesis. This is usually required in cases of infantile paralysis producing flail shoulder; the best permanent results are obtained if the operation is delayed until the age of puberty.

A sand-bag is placed behind the shoulder, an incision is made from just above the tip of the acromion downwards in the line of the deltoid fibres. The muscle will be thin, and is split in the line of its fibres; the capsule is divided freely and the biceps tendon preserved. The head of the humerus is brought out into the wound. The articular cartilage is removed, and the head shaped so that it will fit into the small glenoid fossa. This is carried out most easily by entirely removing a portion of the front and back and then taking the articular cartilage only off the central portion, which can be shaped to fit the glenoid subsequently. During the shaping of the head the operator must realise that in a child the arm will be fixed in a position of 90 degrees abduction and 30 degrees external rotation, with the elbow in front of the body line. The abduction should be about 70 degrees in an adult. The articular cartilage is then removed from the glenoid and the head fitted against it. The wound is closed, and a large plaster is applied round the trunk and over both shoulders and the arm of the affected side (see fig. 2331). The limb must be put in the position already described, with the elbow flexed to about a right angle and the wrist dorsiflexed. A window can be cut above the shoulder and over the wound for removal of the stitches. The plaster should remain in place for three months. Subsequently, movement of the limb is obtained by the action of the muscles on the scapula.

Additional aids to the fixation of the humerus to the scapula can be obtained by: (1) Driving a peg of beef bone or a bone graft through the head into the glenoid; and (2) separating the greater tuberosity

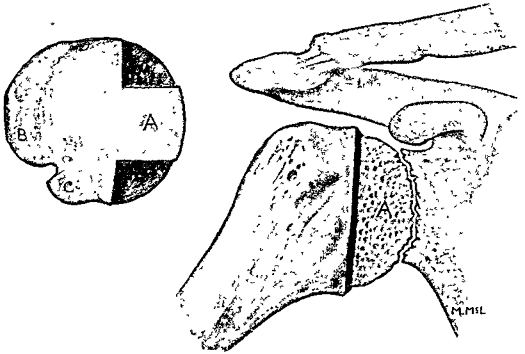


Fig. 2329.—Arthrodesis of the shoulder.

Left hand fig.—The trimming of the head of the humerus has been commenced by removal of two lateral portions, leaving the central piece A, which is to fit into the glenoid cavity. A is still covered by articular cartilage; B, great tuberosity; C, small tuberosity.

Right-hand fig.—Head of humerus and glenoid in apposition after removal of the articular cartilage from both.

Fig. 2330.—Combined intra- and extra-articular arthrodesis of shoulder. The great tuberosity has been elevated and the acromion process, after being bared on its surfaces, placed between shaft and tuberosity. The clavicle and spine of the scapula have been divided to allow the acromion to drop.

from above downwards, leaving it hinged below, and by cutting through the acromion process and, after removing the soft tissues attached to it, inserting it between the greater tuberosity and the bone (see fig. 2330).

Extra-articular Arthrodesis. This is carried out through a similar incision prolonged upwards, and by inserting the acromion, after its

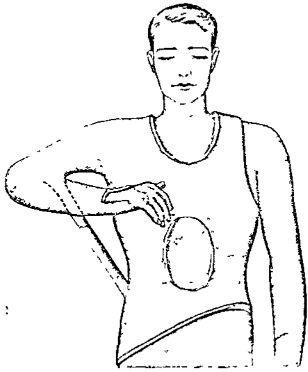


Fig 2331.—Shows plaster applied to trunk and upper limb after arthrodesis of the shoulder.

surfaces have been freshened, into a groove between the greater tuberosity and the humerus in the manner already mentioned. This is facilitated by dividing the clavicle 1½ inches from its outer end and the spine of the scapula at a similar distance (see fig. 2330).

Recurrent Dislocation of the Shoulder

When repeated dislocation of the shoulder occurs with little trauma, operative treatment offers complete cure to a large percentage of patients. Epilepsy is no contra-indication. A variety of operations are still carried out, all of which have definitely taken the place of arthrodesis, as full movement should be obtained by any one of them. Most of those in use to-day are intended to prevent the recurrence of the dislocation by altering the normal periarticular structures and yet allowing full movement. The pathology of the condition, as to whether the bone, capsule or muscle tissue is the primary lesion, is not considered in any

of these operations except in that of Bankart. Yet a high percentage of good results is reported by the advocates of each.

The operations are of two types:

(1) Those designed to prevent recurrence by the introduction of a sling; (*a*) Of muscle. Clairmont's operation consists in separating a strip of the posterior border of the deltoid, carrying it forward through the quadrilateral space, and fixing it to the subscapularis tendon. This operation is theoretically suitable in cases of dislocation when the primary displacement is downward; (*b*) Of tendon. Nicola's operation (*Jl. Bone and Joint Surgery*, 1934, XVI, 663) consists in passing the tendon of the long head of the biceps through the head of the bone. The bicipital groove is exposed by an incision through the anterior part of the deltoid. The biceps tendon is exposed up to the joint by dividing the transverse humeral ligament which keeps the tendon in the groove. The tendon is divided an inch below the lower border of the ligament. With a $\frac{1}{4}$-inch drill a hole is made, starting in the bicipital groove 1 inch distal to the small tuberosity and passing upwards in the line of the tendon, but coming out through the articular surface a half to three-quarters of an inch from the edge of the articular surface. The tendon is passed through this from above downwards and sutured to the distal portion; the transverse humeral ligament is sutured back and also stitched to the biceps tendon after abducting the arm. Fixation with the arm beside the chest wall is employed for two weeks.

(2) Operations on the joint itself, or combined with some other procedure: (*a*) Plication of the capsule alone is seldom curative and is not recommended; (*b*) Repair of the glenoid ligament alone or with plication of the capsule and shortening of the subscapularis tendon.

Bankart advocates the following operation as he considers that when the dislocation occurs " the head shears off the fibrous capsule of the joint from its attachment to the fibro-cartilaginous glenoid ligament." A sand-bag is placed behind the scapula, and the anterior incision for exposing the shoulder joint is employed. The coracoid process is divided with an osteotome and drawn downwards with the muscles attached to it. The tendon of the subscapularis is defined, divided from the humerus, and drawn inwards. The anterior aspect of the shoulder joint is now exposed. The glenoid ligament may appear as a free edge, and a band of fibrous tissue forming the border of the torn capsule may be seen running from above downwards; if it appears flat, it should be elevated and kept in this position with a small wedge of bone. The fibrous capsule should then be fixed to the bone

along the anterior margin of the glenoid. The subscapularis tendon and detached coracoid process are re-attached and the wound closed. The arm is kept at rest for four weeks before active and passive movements are commenced.

(c) By the formation of a bony buttress in front of the joint and

Fig 2332.—Clairmont's operation for recurrent dislocation of the shoulder. A strip of deltoid is fixed to the small tuberosity.

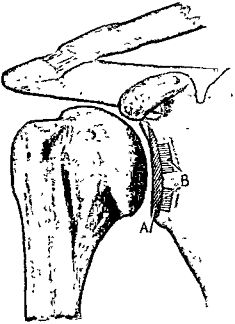


Fig 2334.—Bankart's operation for recurrent dislocation of the shoulder.
A Elevated glenoid lip.
B. Bone grafts.

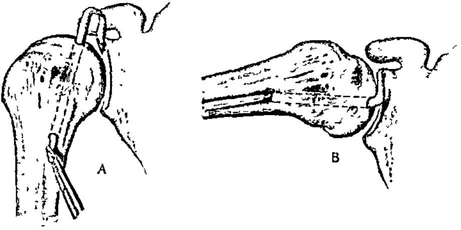


Fig. 2333.—Nicola's operation for recurrent dislocation of the shoulder.
A shows the tendon of the biceps drawn through a drill hole.
B shows the tendon *re sutured to the divided end.*

by shortening of the subscapularis tendon, with plication of the capsule if this is loose.

The coracoid process, the front of the joint, and the subscapularis muscle are exposed by separation of the anterior fibres of the deltoid. The coracoid process is split obliquely from before backwards, so that the tendon of the coraco-brachialis and the short head of the biceps can be turned downwards.

The tendon of the subscapularis is divided ½-inch from its insertion. The anterior portion of the capsule is examined and, if lax, plicated. The subscapularis tendon is overlapped and the slack taken up as it is united ; stitches are passed through the aponeurosis of the two pieces of coracoid process, so that the free portion (to which the coraco - brachialis and biceps are attached) will unite to the fixed piece, but tilted downwards so as to form a bony block in front of the joint. After closure of the wound, a large pad of wool is placed in the axilla, the elbow is bent to a right angle, and the arm is fixed in plaster to the side of the thorax for ten weeks. In Oudard's original operation the coracoid was lengthened by insertion of a graft.

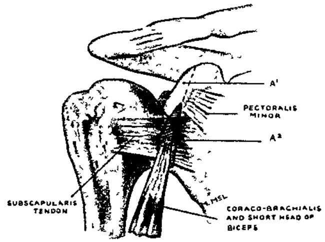


Fig. 2335.—OPERATION FOR RECURRENT DISLOCATION OF THE SHOULDER (*after Oudard*)
A¹ Indicates lateral half of coracoid process divided at the dotted line.
A² Indicates the new position of the lateral half of the process.

There is no doubt that successful treatment of this condition has been carried out by each of these methods. In view of the fact that bony, capsular or muscular lesions may be present, it is certain that the routine use of one method is unlikely to be curative in every case, except probably by the employment of Bankart's operation. The sling operations are less in favour at the present time than ten years ago because Clairmont's operation is extensive and failures have been reported. It is suggested that the failures are due to the fact that the success of the operation may depend on the formation of a pad, and that in course of time this pad diminishes in size. Nicola's operation necessitates injury to the joint, and undoubtedly the tendon will absorb. Bankart's operation has produced good results but is difficult,

and it is perhaps questionable whether it
so extensive an operation as this is; it
satisfactory results are produced because mor
the right place to prevent further dislocation
employed. The last method is popular in Fran
ence of it has been so satisfactory that I have
The length of time the shoulder is immobil
may possibly be a factor in preventing furthe

ELBOW JOINT

Arthrotomy. (1) For infective arthritis, th
posteriorly, either by one incision through th
anconeus on the outer side of the olecranon,
second incision placed on the inner side of the
are in the line of the limb over the swelling
of the joint. It is advisable to avoid making th
side of the olecranon owing to the proximity of

(2) For loose bodies in the elbow joint. Th
should always be made on the outer side if possib
be the method of choice in operations such as th
head of the radius and for fixation of a displaced
on the internal epicondyle should be carried
incision.

The approach to the outer side of the joint
matic tourniquet is employed. The elbow is plac
the arm abducted from the side. In an adult th
1½ inches above the external epicondyle and
over that bony point and along the line of the
of the radius for 2 inches beyond the elbow join
and subcutaneous tissue is reflected forward. Th
extensor muscles arising from the external epic
the line of its fibres for 2 inches, so as to expose th
head of the radius and the capitellum. Care mu
incision is not carried down as far as the point wher
osseous nerve winds round the neck of the radius
the operation it is considered that the operative
carried out through an incision of this size, the a
divided from the external epicondyle and retra
capsule is incised on the outer side of the joint, an
so as to expose the head of the radius and the an
capitellum. A more extensive opening of the join

gently removing the anterior part of the capsule from its attachment to the humerus. Such an approach will make it possible to remove a loose body from the anterior part of the joint or to carry out an operation on the capitellum, or on the head or neck of the radius. The capsule must be closed on the outer side, and the origin of the muscles reattached to the external epicondyle. A line of sutures is placed in the divided aponeurosis of the extensor muscles and the wound closed. The

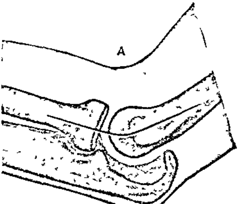
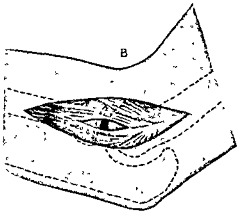


Fig 2336—EXPOSURE OF THE RADIO HUMERAL JOINT
A shows skin incision
B shows the extensor aponeurosis and capsule divided in the direction of the fibres



limb is placed in a light plaster with the elbow at a right angle and the forearm supinated. It is kept at rest for three weeks before active movements are commenced. Massage must not be employed after this operation.

Excision of the elbow joint. This operation consists in the removal of: (1) The lower end of the humerus by a transverse line drawn through the middle of the internal epicondyle; and (2) the head and neck of the radius and of the upper end of the ulna at the level of the neck of the radius. The diseased tissue (if any) is dissected out, but every endeavour is made to preserve the insertion of the triceps and the external lateral ligament.

The operation is indicated: (1) For tuberculosis of the elbow joint when conservative methods are not leading to a successful issue; and (2) in certain cases of suppurative arthritis following compound comminuted fractures involving the joint. This operation can be carried out when sinuses are present, and the wound be drained subsequently, whereas an arthroplasty is not advocated in the presence of infection.

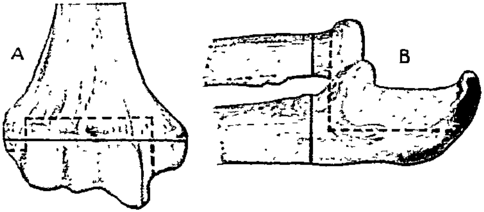


Fig 2337.—The bones of the elbow joint showing.
A. Lines of section of the bones in excision (continuous lines).
B. Lines of section in arthroplasty (dotted lines).

The operation through a lateral incision, as described by Kocher, is the one usually practised. Flexion and extension are generally satisfactory, but lateral instability often occurs after excisions of the elbow.

The *after-treatment* consists in keeping the joint at right angles for two weeks; from that time movement is encouraged, but the arm must be kept at rest between the exercises. It is probably advantageous to keep it in different positions of flexion and extension for four to five weeks before discarding all splinting. Electrical treatment and massage to strengthen the muscles will help to prevent lateral instability.

Arthroplasty. Indications: (1) *Traumatic conditions*—(*a*) Certain comminuted fractures of the elbow joint; (*b*) bony or fibrous union following fractures involving the joint. In adults, when a simple comminuted fracture of the lower end of the humerus has injured the articular surface to such an extent that good function of the joint is unlikely to occur, an arthroplasty carried out within ten days of the injury is a sound procedure. In fact, the result is likely to be better than when the operation is carried out late owing to irregular bone formation, contraction of the capsule, and wasting of the muscles which are such frequent sequelæ of severe injuries to the elbow joint.

(2) *Ankylosis following infective arthritis.* Arthroplasty is seldom advisable in any case of tuberculosis of the joint. It is important to

delay this operative procedure until the surgeon is satisfied that no infective process is present or likely to be brought to light by any operative procedure. Good results are reported when there has been bony ankylosis, and undoubtedly best function follows those operations which are carried out when the bones have been little damaged by an infective arthritis.

This operation to regain movement is probably of little value for a labouring man, who can do moderately hard work with an ankylosed elbow, provided it is not painful. It is recognised that fibrous union of the elbow is not as painful a condition as it is in the knee or ankle joint. However, a flail elbow is a particularly serious disability for the workman, and is found to arise as the result of gross injury to the bones or of imperfect technique in carrying out an excision.

Technique. The technical details of an arthroplasty cannot be standardised, as each case must be treated on its merits. A pneumatic

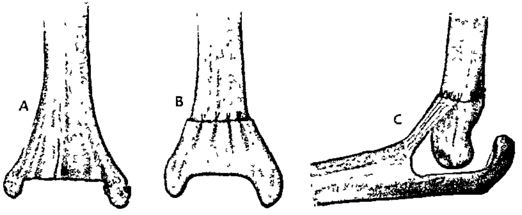


Fig. 2338.—Arthroplasty of the elbow joint.

A. The lower end of the humerus prepared

B. The lower end of the humerus covered with fascia

C. The covered lower end of the humerus replaced in the sigmoid fossa. The fascia over the humerus has been stitched to the anterior part of the capsule of the joint.

tourniquet is used. The skin incision must depend on the position of any scar tissue. It is essential that it should be sufficiently long to give free access to the joint. A posterior incision 7 inches in length, with the centre over the tip of the olecranon, provides good access. As there are certain advantages in the incision not being directly over a bony point, an incision of similar length can be employed on the lateral side of the triceps tendon and carried down between the radius and ulna. The triceps aponeurosis is divided at the joint level, and the tendon and a thin slice of olecranon, including the tip, are removed with an osteotome and retracted upwards. The ulnar nerve is isolated and retracted, and the lower end of the humerus is cleared. As it is usually necessary to

remove the lower end of the humerus above the epicondyles, it is advisable now to remove the epicondyles and their muscle attachments with a thin osteotome. If there is bony union, this must be broken down by means of a gouge. If it is a case of fresh fracture, loose fragments of bone are removed. If there is fibrous union, the joint is broken open. The lower end of the humerus is then brought out into the wound, care being taken that the periosteum is not stripped up. Before dealing with this, the radius and ulna are examined. These should be interfered with as little as possible, but if the head of the radius is devoid of articular cartilage, it is better to remove the head and a small portion of the neck unless the surgeon has decided to do this at a second operation. With regard to the ulna, it is essential to leave or remodel the great sigmoid fossa. If articular cartilage no longer exists, it will be necessary to remodel this, but every endeavour should be made to preserve the olecranon process. The loss of the coronoid process does not interfere with stability to such an extent. The lower end of the humerus is now fashioned by removal of the old articular surfaces up to the level of the olecranon fossa. Some surgeons aim at endeavouring to reshape the bone into what it was before, but the majority prefer to cut the bone just distal to the olecranon fossa so that the divided surface is quadrilateral. A rasp or file is now used over the raw bony areas. The humerus should then be placed in the sigmoid fossa to test the fit.

The next step is to cover the lower end of the humerus with a flap. This is not employed when the operation is being carried out for a recent fracture, but by most surgeons for other conditions. The flap should consist of a free fascial flap removed from the thigh, or of a musculo-aponeurotic flap removed from the deep surface of the triceps. In either case the flap is sutured round the lower end of the humerus and preferably attached at one or two places to the front of capsule of the joint. Care is taken that the forearm bones are in correct relationship to the humerus, and the addition of a few stitches from the capsule to the fascial flap will help to prevent the humerus from losing its correct relationship to the ulna. The epicondyles are fixed back to the humerus, the olecranon and triceps aponeurosis are sutured into place, and the wound is closed. After application of dressings, the arm is put in plaster, flexed just above a right angle in full supination. The stitches are removed in two weeks and a posterior plaster trough made; movement is then commenced, future treatment being as for other cases of arthroplasty.

Operations on the head and neck of the radius are described in Chapter IV of this section.

INFERIOR RADIO-ULNAR JOINT

Ankylosis of this joint is treated by an operation on the lines devised by Baldwin. An incision is made over the lower part of the ulna between the flexor and extensor carpi ulnaris, the ulna is exposed, and a point $1\frac{1}{2}$ inches from the head of the ulna is located. Half an inch above and below this point the periosteum is incised in a circular fashion, and the ulna is then cut through in two places so as to remove less than 1 inch with the periosteal sheath. A small portion of the muscular tissue in the neighbourhood is stitched round the proximal end of the ulna, and the wound is closed. The part is kept at rest for three weeks. Good results are obtained as union does not occur between the two ends of the ulna. (*Orthopædic Surgery of Injuries*, R. Jones. Oxf. Med. Publs., 1921.)

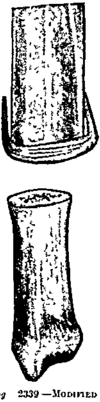


Fig. 2339.—Modified Baldwin's operation. A cylindrical portion of the ulna has been excised above the pronator quadratus. A flap of muscle has been turned over the proximal end.

WRIST

Arthrotomy for purposes of drainage is seldom required. The wrist joint is opened for removal of part or the whole of the scaphoid and for unreduced dislocation of the semilunar bone. The operation is described in the chapter on fractures (see page 4444).

The operation of excision of the wrist joint was at one time carried out in cases of tuberculosis, but success of this operation seldom equals the conservative treatment, so that operative measures for this condition are limited to removal of sequestra only; this is seldom required except when sinuses have persisted for some time.

When ankylosis is present in a bad position or when there is lipping of bone on the back of the radius and carpal bones so as to limit dorsiflexion, operative treatment is indicated. The operation of arthrodesis is advisable for the former; the bony lipping can be removed alone, or in more severe cases arthrodesis also can be performed. Arthroplasty of this joint is not recommended; its success will enable natural movement as well as flexion to be carried out, but in the cases reported, the degree of dorsiflexion which is so valuable has not always been maintained.

Technique of Arthrodesis. A pneumatic tourniquet is employed round the arm. An incision—4 to 5 inches long, with its centre over the wrist joint, is made along the radial side of the extensor proprius indicis.

The veins are clipped and divided, the posterior annular ligament is cut, and the tendons are retracted. The line of the wrist joint is defined, and a chisel inserted so as to divide the lower end of the radius at right angles to the shaft but obliquely from behind forwards. The proximal surfaces of the scaphoid and semilunar bones are removed. The ulna and cuneiform are cut through similarly, so that a wedge of bone is removed with the base at the back and the point of the wedge forward. This will make it possible for the wrist to be dorsiflexed 45 degrees. It

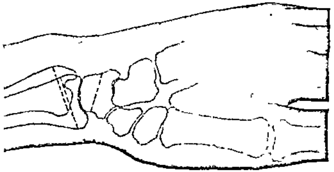


Fig. 2340.—Arthrodesis of the wrist joint. The lines indicate lines of section of the bones to fix the wrist in dorsiflexion.

is important to divide the radius and ulna right through to the front. The bones should fit accurately.

It may be possible to insert one or two catgut sutures to help to hold the bones together before replacing the tendons in their correct position and closing the annular ligament and skin. A plaster is applied which includes the thumb and first phalanges and extends up to the elbow joint, care being taken that the wrist is in the position of dorsiflexion already mentioned. In two weeks the stitches are taken out and a more tightly-fitting plaster is applied. Movement is encouraged in such portions of the fingers as is possible. At the end of ten weeks from the time of operation, the plaster is removed and a skiagram taken to see if bony ankylosis is secure.

METACARPO-PHALANGEAL JOINTS

Operation is required on these joints for open reduction of dislocations when closed reduction has failed. If the operation is carried out soon after injury, it will not be difficult to see what structure is preventing reduction. This can be elevated out of the joint and the dislocation reduced. When a dislocation has been present for some weeks, it is probably best to attempt open reduction on similar lines.

Arthroplasty is sometimes practised for such a condition and for *stiff joints due to other causes*; however, good movement after mobilising this joint is seldom obtained and fibrous union is the usual

sequence. In performing arthroplasty, incision is made to one side of the extensor tendon; the head of the metacarpal bone is preserved as much as possible, the cartilage only being removed, but the base of the phalanx is cut away so as to make a larger joint space. A sheet of fascia from the thigh is fixed round the head of the metacarpal bone and the tissues surrounding the joint are brought together to re-form the posterior part of the capsule. It is essential to apply extension to the finger; this is best carried out by passing a finger-pin and stirrup through the pulp of the finger, and fixing this with tape to a notch in a piece of wire extending beyond the finger distally and attached to a plaster cuff round the wrist as is used in a case of fractured phalanges (see fig. 2391). Finger movements should be commenced two to three weeks after the operation; the extension can be continued for five to six weeks, being removed daily for exercise.

TERMINAL INTERPHALANGEAL JOINT

Arthrodesis of this joint, particularly in the first and second fingers, is useful in unreduced fracture-dislocations which are painful. An incision is made to one side of the joint in a line with the edge of the nail. The joint is exposed, articular cartilage removed with a thin-bladed osteotome, and the bone shaped so that the terminal phalanx is slightly flexed on the second phalanx. It is important that the two pieces of bone should fit snugly; this may be made possible by passing catgut sutures through the periosteum or by shaping the second phalanx to fit into the terminal one. The finger is splinted with a malleable metal splint or light plaster for six weeks, when an X-ray picture is taken to see if union is firm.

SACRO-ILIAC JOINT

The operation of arthrodesis of this joint is performed for sacro-iliac arthritis (sub-acute, particularly after pregnancy, and chronic), and for tuberculosis. Both intra- and extra-articular arthrodesis is practised. The extra-articular operation is obviously suitable for either condition and, although some surgeons practise the intra-articular operation for either condition, it is considered that tuberculosis should be treated by the extra-articular arthrodesis only.

The cases of low backache due to arthritis are usually treated by physical methods—heat, massage, perhaps manipulation and a corset—before resorting to operation, even when X-ray changes show arthritis. Before deciding on an operation, it is most necessary to determine if the signs and symptoms are due to arthritis of the sacro-iliac joint only, to

a similar condition of the lumbar spine, or to both. In the first case, sacro-iliac arthrodesis is indicated; in the second, fusion of the lumbar spine; and in the third, a combination of these two operations.

In the case of tuberculosis of the sacro-iliac joint, conservative treatment by rest on the back in a plaster bed or similar apparatus will form the most important part of the treatment, and there is a divergence of opinion as to whether any operative treatment is advisable. There are three alternative lines of treatment:

(1) Sacro-iliac arthrodesis as soon as the diagnosis is made;

(2) Exposure of the affected area, removal of as much disease as possible, and fixation with a bone graft extending through the area of the disease; or

(3) Arthrodesis at the termination of the conservative treatment when the symptoms, signs and X-ray appearance suggest that the disease is no longer active.

Some surgeons consider that an abscess is not a contra-indication to the operation, but in the presence of sinuses surgery is definitely contra-indicated. Those who favour early operative treatment are influenced by the fact that the disease is recognised as a serious manifestation of tuberculosis and that early steps to allay the condition surgically are likely to cure it more quickly, and, further, to limit or prevent other foci of tubercle appearing elsewhere in the body. Most surgeons are content to treat the condition conservatively only if other foci of tubercle are active. Experience of operative treatment for this condition is still limited. At the present time I consider that the best procedure is to perform an extra-articular arthrodesis at the termination of the conservative treatment.

The extra-articular arthrodesis described by Verrall is practised by a number of British and French surgeons, both for sacro-iliac arthritis (uni- or bi-lateral) and for tuberculosis. The operation necessitates removing a bone graft from the tibia. The results on the whole are gratifying, but absorption of the graft on the medial aspect of the ilium may occur. Those who are familiar with this operation will probably employ it for both conditions in preference to the operation of Smith-Petersen which is intra-articular and therefore, in the author's opinion, not suitable for tuberculosis.

There are obvious advantages in removing the bone graft from the ilium without employing a tibial graft; it is considered that for unilateral sacro-iliac arthritis the operation of Smith-Petersen is the one of choice, but that for unilateral sacro-iliac tuberculosis an extra-articular operation, using a graft from the ilium, is to be preferred.

Extra-articular Arthrodesis. A week prior to any one of these operations, a plaster bed should be made, so that the patient can be placed in it at the end of the operation.

The technique of *Verrall's operation* is as follows (fig. 2341):

The skin incision consists of a semilunar flap with the base downwards, the convexity being over the top of the 5th lumbar spine. Both posterior superior iliac spines are exposed, together with the muscles on the back of the sacrum. The spines are cleared of muscle and aponeurosis, and the spinous process of the sacrum which intervenes between these two is removed with a large pair of bone forceps. A tunnel the size of a little finger is made in each ilium in front of the posterior superior spines. A bone graft of the required size is cut from

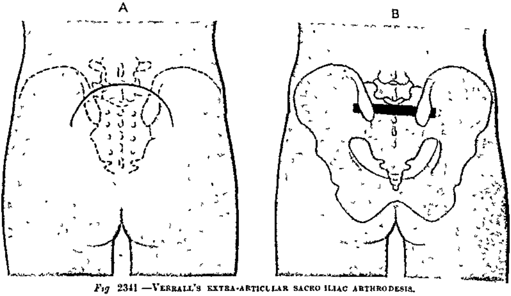


Fig. 2341.—Verrall's extra-articular sacro-iliac arthrodesis.
A. Skin incision.
B. Graft from tibia *in situ*.

the tibia and driven through the ilium deep to the muscles on the back of the sacrum and into the other tunnel. It should lie in contact with the raw area made on the sacrum by the removal of the spinous process.

Intra-articular Arthrodesis of Smith-Petersen. The skin incision consists of a 4-inch incision along the posterior two-thirds of the iliac crest which is continued in a curved fashion round the posterior superior iliac spine and then forwards in the line of the gluteal fibres for 3 inches from the posterior superior iliac spine. The incision is carried right down to the bone (see fig. 2342).

With a broad periosteal elevator the periosteum and overlying muscle are reflected downwards and forwards, commencing along the outer border of the posterior part of the crest of the ilium. This is continued until the sacro-sciatic notch is exposed. The flap is held retracted by the

assistant, while the operator maps out on the bone a rectangular area which he considers to correspond to the sacro-iliac joint. The inferior border of this joint corresponds to a line just above the sacro-sciatic notch and the anterior border to the medial gluteal line. The piece of bone marked out should be approximately $1\frac{1}{2}$ by $1\frac{1}{4}$ inches. With a thin-bladed osteotome this rectangular piece of bone is removed so as to make a window down to the sacro-iliac joint. It should extend

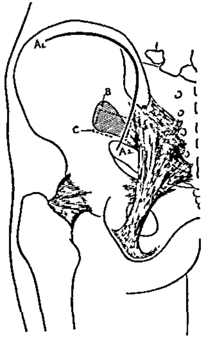


Fig. 2342.—Smith Petersen's intra-articular sacro iliac arthrodesis.

A1, A2 indicates skin incision.

B represents the area of ilium overlying the sacro-iliac joint. The rectangle C indicates the bone block which is cut out and later counter-sunk.

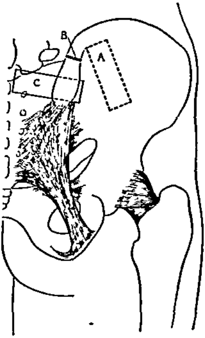


Fig. 2343.—Extra articular arthrodesis of sacro-iliac joint by use of bone graft from ilium.

A indicates graft cut.

B indicates the line of division of posterior iliac spine

C indicates the graft in position resting on rawed surface of sacrum and deep to posterior spine, which is refixed superficial to graft.

posteriorly into the inferior sacro-iliac ligament. The joint surface is then removed with a gouge or large spoon so that the window extends right into the sacrum. The rectangular piece of bone which has been removed is examined and the cartilaginous surface of it is cut away. It is then replaced and driven home, being counter-sunk as far as possible so that the cancellous tissue comes in contact with the cancellous tissue of the sacrum. If it is well home, it should fit very tightly. The muscles and periosteum are stitched back in place and the wound is closed.

Extra-articular arthrodesis may be carried out as follows: The

exposure is made as for Smith-Petersen's operation. A bone graft consisting of the outer table and cancellous tissue of the ilium, measuring 2 inches by 1 inch, is cut at some distance from the sacro-iliac joint as is indicated in figure 2343. The posterior superior spine is removed with a thin osteotome, $\frac{1}{2}$-inch of bone being elevated and turned downwards with the attached sacro-iliac ligaments. The muscles on the posterior surface of the sacrum are raised and the surface of the bone roughened; the graft is placed transversely on this raw area of the sacrum and over the area from which the posterior superior spine was removed. The posterior superior spine is then re-attached, the muscles are stitched back in place, and the wound closed.

HIP JOINT

The two easiest methods of approach to the hip joint are: (1) Antero-lateral; and (2) Lateral.

The former is used: (*a*) for drainage of the hip joint for acute arthritis; (*b*) for operations on the joint itself in children; and (*c*) sometimes for intra-articular arthrodesis.

The lateral approach is employed for: (*a*) extra-articular arthrodesis; (*b*) intra-articular arthrodesis; and (*c*) arthroplasty.

Exposure of the hip joint by the antero-lateral incision. This commences just below the crest of the ilium, 3 inches (in adults) behind the anterior superior iliac spine, and is carried forwards to below the anterior superior iliac spine and then downwards for 5 inches in the

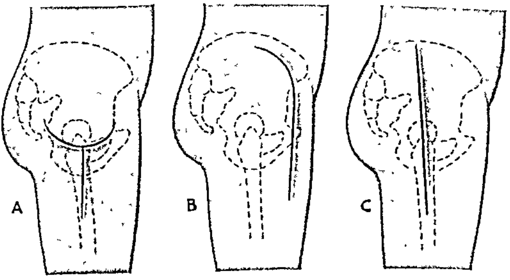


Fig. 2344.

A. Skin incision—termed the "goblet incision"—employed for most operations on the hip joint.
B. Antero-lateral or Smith Petersen incision for operations on the hip joint. This is particularly suitable for operations in children.
C. Lateral incision for hip joint, particularly suitable for extra articular arthrodesis.

line of the limb over the front of the tensor fascia femoris. The flap is turned outwards. The glutei and tensor fascia femoris are stripped from the ilium, and the interval between these muscles and the sartorius and rectus femoris is dissected. A branch of the external circumflex artery will require ligation. It will be necessary to remove the origin of the rectus femoris from the anterior inferior iliac spine in order to expose the capsule freely.

The technical part of the operation, whether it be an open reduction for a congenital dislocation, making a shelf for congenital dislocation, or drainage of the joint, will now be carried out. The muscles are fixed back in place with catgut sutures and the wound closed. If counter-incision for drainage in infective cases is necessary, this is done before the wound is closed.

Lateral incision. (i) For an extra-articular operation, a vertical incision is made in the line of the femur over the great trochanter up to the crest of the ilium: it should extend 3 inches below the great trochanter (fig. 2344c). (ii) For intra-articular operations, more room is generally necessary, and the "goblet incision" of Murphy is employed as is shown in figure 2344A. The method of exposing the hip joint is described subsequently.

Arthrodesis: Intra- or extra-articular arthrodesis may be carried out on this joint.

Indications: (*a*) Certain cases of unilateral osteo-arthritis; (*b*) Certain cases of tuberculosis; and (*c*) Flail hip joint in some cases of infantile or other paralysis.

The object of treatment of osteo-arthritis of the hip joint is the relief of pain; as a first measure of relief it is usual to advise a caliper splint to take the weight off the joint. A number of operations have been devised and it is impossible to dogmatise on the treatment of this disabling condition, particularly in elderly people. If operative treatment is contemplated, the first consideration should be whether the patient's general health, adiposity, and age will enable him to stand the operation and the after-treatment which will necessitate fixation for some weeks. Any operation is of considerable magnitude, whether it be an arthrodesis to produce bony union and so a painless joint, Jones' operation which produces a pseudarthrosis in the position of the neck of the femur, or a cheilotomy which consists in the removal of osteophytic outgrowths after division of the capsule. Arthrodesis for this condition is usually carried out by the intra-articular method, but there is no reason why the extra-articular should not be employed.

Investigation of the X-ray appearance of the hip joint after it has

been affected with tuberculosis shows that destruction of bone is common, malposition (flexion-adduction deformity) is present in many cases, and fibrous union generally occurs, so that a painful joint at the end of a tedious treatment occurs in a big proportion of cases at some time or other during the patient's life. Consequently, the tendency of surgeons of to-day is to advocate extra-articular arthrodesis, either as soon as the disease is diagnosed or at the termination of the conservative treatment. In children, free movement *may* occur in cases of early synovial tubercle and when the disease has been in the innominate bone and not in the femur. If an operation is carried out during an active tuberculous condition, a firm bony union is more likely to occur if the diseased area is not exposed.

In cases of paralysis of the lower limb, one rarely finds muscular control of the knee joint associated with excessive weakness of the muscles controlling the hip joint. When this is the case, an arthrodesis of the hip joint can be carried out. Patients with infantile paralysis accompanied by a flail limb are seldom able to walk after fixation of the hip and the knee, and these cases are often complicated by paralysis elsewhere.

Intra-articular Arthrodesis. Technique. The "goblet incision" is employed. The skin incision is somewhat undercut, and the tensor fascia femoris and glutei are separated. A broad osteotome is applied to the base of the great trochanter and this prominence removed, the bone being cut in a line with the upper border of the neck of the femur. The trochanter is drawn upwards and backwards with slight dissection so that the glutei muscles are displaced in this direction. The upper surface of the neck of the femur and capsule are then exposed, and the capsule is divided from above downwards and from before backwards. The head of the femur is then dislocated from the acetabulum, and the articular cartilage is removed from its surface. The acetabulum is then cleared of articular cartilage. These procedures are limited by many surgeons who only remove the cartilage from the superior and posterior surfaces of the head of the femur and from the corresponding surfaces of the acetabulum. One advantage of this is that the fit between head and acetabulum is somewhat better, and bony union is more likely to occur over the area where it is particularly required (see fig. 2345A).

The head is replaced in the acetabulum and fitted in; if bony surfaces do not come in contact, further trimming is necessary. Stitches through the capsule help to hold the bones in apposition. The limb is then held by the assistant in slight abduction and flexion, and the great trochanter is brought back on to the femur. It is usually found that

if this is placed on its old seating, the muscles will be lax, and that by fixing it further down the femur the head will not only be held better against the acetabulum but the abduction will be maintained; hence, a new bed is made for the trochanter lower down on the outer side of the shaft of the femur where it is fixed by two pegs or nails; the muscles are united with stitches and the wound closed. There is no doubt that a proportion of cases do not obtain bony union after this operation so that it is advantageous to employ extra-articular fixation as well.

Extra-articular Arthrodesis. Technique. This operation consists in the formation of a bridge of bone between femur and ilium to prevent movement at the hip joint. Various methods have been described as the evolution of this operation has developed, and the type of operation must depend on the condition of the patient and the nature of the lesion for which it is carried out.

Two types of operation are frequently employed:

(1) When the bridge is taken from the femur or the ilium; and

(2) When the graft is from the tibia.

If the condition is carried out for tuberculosis, tuberculous bone should not be used and the graft should not extend through the joint;

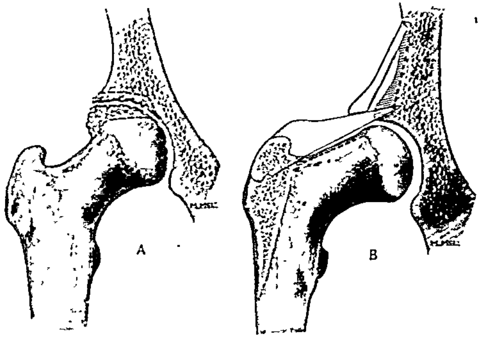


Fig. 2345.

A. Arthrodesis of the hip (partial extra articular). The bone and cartilage between the dotted lines are removed and the head of the femur is approximated to the bared roof of the acetabulum. B. Hibbs' arthrodesis of the hip joint. The anterior two-thirds of the great trochanter and a portion of the shaft are rotated after removal of the upper surface of the neck of the femur. A flap of ilium is also raised. In this diagram the graft is not shown in contact with the neck of the femur, in order that it may be clear what area of the neck of the femur is removed.

whereas, if it is carried out for non-suppurative arthritis, the strongest arthrodesis will be made by a " bridge-graft " from the ilium to the trochanter, resting directly on the neck of the femur.

Technique of Hibbs' operation. The lateral approach with the linear incision is employed by most surgeons. The muscles are separated in the interval between the gluteus medius and the gluteus maximus, and the capsule of the joint is exposed. The anterior half or more of the great trochanter and 2 to 3 inches of the adjoining femoral shaft are removed with a thin osteotome and separated in the form of a wedge. A flap of the ilium is turned up from above the acetabulum, the base of the flap being left attached. The wedge of femur is then swung round so that the pointed portion from the shaft fits into the ilium. The flap of ilium is pressed down on to the bridge and stitched over it. The stitches are also applied to keep the trochanter on the femur. As Hibbs describes this operation, the upper surface of the neck of the femur is also removed and the graft rests directly on the neck of the femur; this makes a firm arthrodesis, but should not be employed in cases of tuberculosis. Muscles are stitched back in place and the wound is closed. If there is deformity, an osteotomy must be performed later unless an intra-articular operation has been carried out at the same time.

Technique of osteoplastic flap from the ilium (after Mathieu and Wilmoth). The hip joint is exposed as for intra-articular arthrodesis of the hip by the removal of the great trochanter. A flap of bone is turned down from the ilium and fixed between the trochanter and femur. It is important that the flap from the ilium should keep good contact with that bone, as it is inclined to get away. If it is loose it should be fixed back by other portions of bone removed from the ilium (see fig. 2346).

Technique of Albee's operation. The hip joint is exposed but the trochanter is not removed. A graft is cut from the tibia and driven through a tunnel in the great trochanter so that it lies deep to the muscles along the neck of the femur and passes into a hole which is made in the ilium above the acetabulum. This operation can be modified by using a portion of free graft from the femur. This consists of the middle third of the great trochanter and upper portion of the shaft of the femur; the graft is turned round so that the portion from the shaft is driven into the ilium, and the middle portion of the trochanter is again fitted in between the two sides of it which were left standing after the graft was cut. This latter appears to be the easier operation, but the size of the bridge formed is not so large as in the operation of Hibbs though it fits well, whereas the Hibbs' graft does not

fit easily unless the upper surface of the neck of the femur is removed (fig. 2347).

It is important to realise that the relationship of the femur and the ilium must be accurately maintained while the wound is closed, dressings applied and a plaster-cast made. It is of great assistance if the plaster bed is made before the operation so that the patient can be put directly into it. Further, the operation is a severe one for the type of patient who needs it, so that the additional exposure and length of anæsthesia necessary for the application of plaster at the end of the operation are

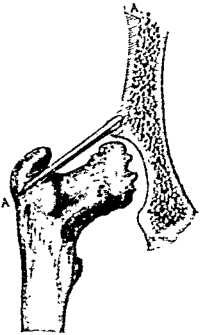


Fig. 2346.—Extra-articular arthrodesis of the hip (*after* [illegible]). Graft from the ilium is fixed between the trochanter and the neck of the femur below and into the ilium above.

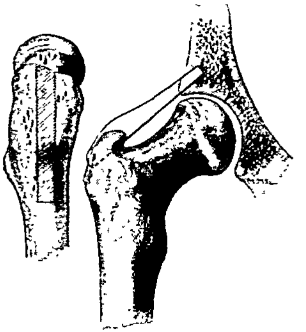


Fig. 2347.—Extra-articular arthrodesis of the hip (*after* *Albee*). A bone graft from the lateral surface of the trochanter and femur is transferred to the ilium above and to the central portion of the trochanter below.

to be avoided. It is seldom that osteotomy and extra-articular arthrodesis can be carried out at the same time. In tuberculous cases, surgeons differ in their opinion as to whether osteotomy should be done first or subsequently. In the osteo-arthritic case, this can be avoided by combining intra- and extra-articular arthrodesis. In every case the plaster must include the foot and leg of the affected side, extending to the knee on the unaffected side and upwards round the lower portion of the thorax. A deep plaster trough—of the plaster-bed type—is most suitable, and can be employed until the patient is allowed to get up. It is advisable that a short spica should be worn when the patient is getting about on crutches for the first few weeks.

Bifurcation operation. This operation, associated with the name of Lorenz, is employed both in adults and in children. In the former it is suitable for cases of osteo-arthritis of the hip joint and for un-united subcapital fractures of the neck of the femur; in children it has been employed in cases of unreduced congenital dislocation of the hip joint. The operation causes only a small degree of shock, takes a short time to carry out, and is accompanied by little hæmorrhage. As an operative procedure, the dangers are few compared with arthrodesis of the hip. More successful results will follow an "open" osteotomy than one carried out through an incision limited to the size of the osteotome.

Technique. An incision is made along the outer side of the line of the femur, 5 inches from the tip of the trochanter downwards. Dissection is carried out on the front of the femur, so as to appreciate the level of the small trochanter and the neck of the femur. With a broad osteotome, the femur is divided upwards and inwards. The bone incision starts below the great trochanter and ends above the small trochanter. The lower fragment is pushed inwards and upwards, whilst the assistant abducts the limb. The fragment should be displaced so that it rests outside the capsule, below the lower border of the acetabulum. For the success of the operation, union must occur between the two divided fragments in the altered position.

After closure of the wound, the limb is secured in plaster, which must include the lower part of the trunk and the thigh of the other limb. Abduction is not required, the limb being square to the trunk. After two months, an ambulatory plaster spica is employed (McMurray).

Arthroplasty of the hip. Indications: (1) Double ankylosis of the hips; (2) Limited painful movement in cases of arthritis, (*a*) subsequent to infection when it is certain that the infective condition is healed, and (*b*) in picked cases of osteo-arthritis of the atrophic type; (3) Rarely in cured tuberculous arthritis.

Undoubtedly this operation is called for most frequently in cases of double ankylosis. Murphy found that the hip joint gave him the best results in arthroplasty.

Technique. The hip joint is exposed by the "goblet incision" using the lateral approach, or by the antero-external incision according to the choice of the operator. The former probably gives the better exposure. After removal of the great trochanter, the hip joint is exposed. If ankylosis is firm, it is necessary to separate the femur from the pelvis by cutting away the upper and posterior surfaces of the head of the femur and then the lower portion of the head. A large gouge will then cut through the deep surface of the head, and with a little

force the remainder of the head can be fractured. If the head is not ankylosed, it is dislocated from the acetabulum. The head of the femur is then reshaped and a deep hollow made in the acetabulum. Careful cutting with a gouge will be as effective as the use of the special bits and a brace which have been devised for this purpose. It is important to smooth the acetabulum and the bony surfaces, to see that there is a big gap between the head and the acetabulum, and to remove all loose bony particles from within and around the hip joint. A piece of fascia lata, which should measure about 4 inches by $3\frac{1}{2}$ inches, is now cut from the thigh. This is placed over the head of the femur and stitched round the neck with a purse-string suture. The head is returned to the acetabulum, the trochanter replaced and the wound closed. The limb is extended on a Thomas splint. A moderate amount of abduction is used and 15-lb. traction for three weeks. The extension is then removed and the patient encouraged to contract the thigh muscles. He may get up in six weeks with crutches, and start to bear weight in eight weeks.

Whitman's reconstruction operation. This was originally devised for un-united fracture of the neck of the femur, particularly when the neck had been considerably absorbed. It is also employed for some cases of monarticular hypertrophic arthritis.

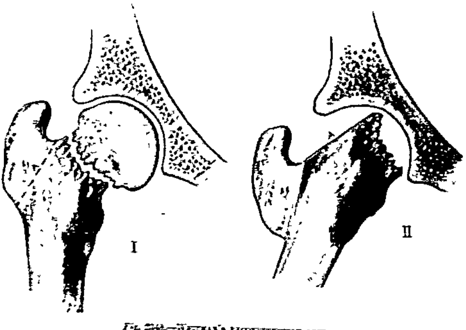


Fig. [illegible].—WHITMAN'S RECONSTRUCTION OPERATION.

I. Shows un-united fracture of neck of femur with absorption of the neck. A indicates line of section of great trochanter from the shaft.

II. The head has been removed. The neck has been placed in the acetabulum and the great trochanter placed on the outer side of the shaft of the femur.

Technique. Whitman employed a semicircular incision similar to the upper part of the goblet incision, but the incision crossed the femur 3 inches below the apex of the trochanter. The interval between the tensor fascia femoris and the gluteus medius is opened and the capsule exposed. With a broad chisel, the base of the trochanter is cut through in the line of the neck and is turned upwards with the muscles attached. The capsule is opened and the greater part of the head removed so that all cartilage, marginal exostoses, and as much of the underlying bone as may be affected in the degenerative process, are removed. In most instances, Whitman removed the whole head. The end of the neck or remains of the head is smoothed and reinserted into the acetabulum. A thin section of bone is turned back from the upper and outer surface of the shaft of the femur and the limb abducted. The trochanter is then fixed to the bare surface on the outer part of the shaft by deep sutures or a peg. The wound is closed, and a long plaster spica is applied in extension and abduction. Whitman appears to vary his after-treatment, allowing some patients to walk in a short spica and crutches after a few weeks, while others are kept recumbent until it is certain that the trochanter has united to the femur. Subsequent to this operation, it is most important that there should be persistent stretching of the limb in the direction of abduction and extension in order to prevent the limb from becoming flexed and adducted.

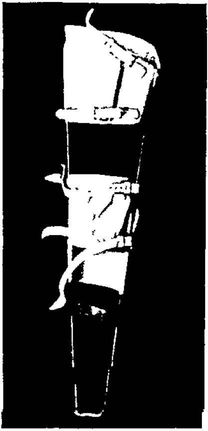


Fig 2349.—Bucket caliper.
(Beckett and Bird.)

After any operation on the hip joint, the majority of patients are more comfortable if they wear a caliper for some months after the operation.

KNEE JOINT

Arthrotomy is required for:

(1) *Suppurative Arthritis.* The operation is described in Vol. II, page 3428. It is undesirable to divide the ligamentum patellæ in order to drain the joint; such an exposure seldom produces better drainage,

and the risk of fixation of the knee in the flexed position which is employed after this incision is considerable. It is doubtful if a limb is saved by this procedure, and it is to be condemned. Drainage of the knee joint in an adult, when pus is present in the joint, is usually followed by ankylosis; it is to the patient's advantage if this ankylosis is bony with the knee fully extended or flexed only a few degrees.

(2) *Exploration of the Joint.*

(*a*) *For diagnostic purposes;*

(*b*) *For removal of loose bodies.*

A tourniquet is used, and the knee is placed on a rest or over two sand-bags so that it is flexed to about a right angle. An incision is made along the inner side of the patella and suprapatellar pouch. The capsule and synovial membrane are divided about ½-inch medial to the patella. Through this incision it is possible to examine the synovial membrane, the cartilaginous surface of the femur, and the anterior portion of the internal semilunar cartilage.

The technical portion of the operation is now carried out, such as removal of synovial membrane for examination. The wound is closed in two layers, synovial membrane being stitched with a continuous suture and the capsule with the same piece of catgut or a second suture of similar nature. A pressure-bandage is applied and no splint employed unless the condition is likely to be painful.

Loose bodies may be removed through the approach just described. If a loose body remains in one situation and is palpable through the skin, an incision should be made directly on to it, but where many loose bodies are present, an endeavour should be made to remove them through one incision. If it is possible to count how many are present in the X-ray picture, they should be recounted as they are removed. It may be advisable to make a second incision on the other side of the joint. For a loose body which cannot be found, there is probably no better method than forcible flushing with saline by means of a sterile Higginson syringe.

If a loose body is in the posterior part of the knee joint, it is necessary to remove it through a posterior incision. The patient is placed on his face with the knee extended. An incision is made just to the outer side of the mid-line and extending for the length of the popliteal space. The external popliteal nerve is exposed and drawn outwards. The *internal popliteal* nerve and vessels are drawn inwards. Care should be taken not to divide or injure the communicans fibularis and communicans tibialis nerves. The knee joint is then flexed and the space between the two retractors dissected down to the posterior liga-

ment; this is incised from above downwards, the loose bodies are removed, a stitch is placed in the capsule, the popliteal fascia is reunited, and the wound is closed.

The approach to the knee joint by *splitting the patella* is undesirable as the injury to the joint is considerable and the risk of traumatic arthritis after the operation is far greater than when the joint is opened through the soft tissues. When it is necessary to expose the joint and displace the patella laterally, this can be carried out by a long incision through the soft tissues to one side of the patella. (See also Vol. II, page 3387.)

(*c*) *Removal of the internal and external semilunar cartilages.* This has been described in Vol. II, page 3365.

(*d*) *Reconstruction of crucial ligaments.* Rupture of the crucial ligaments and fractures of the tibial spine may either be associated or exist alone. The condition is a serious one.

The *diagnosis* of ruptured crucial ligaments is made on: (i) the history of a severe injury to the knee; and (ii) finding that the tibia can be moved forwards or backwards, or rotated inwards when the leg is fully extended.

When the anterior crucial ligament is torn, it is found that the tibia will move forwards on the femur when moved passively with the leg extended, whereas in a posterior crucial ligament injury, the tibia can be displaced backwards when the knee is in the flexed position. It is doubtful if the latter injury occurs alone.

Laxity of the joint due to chronic disease (such as Charcot's disease) can be easily excluded. If, after an injury, laxity of the type described is present, but the knee cannot be extended, there is likely to be a fracture of the tibial spine.

The joint will be swollen owing to hæmorrhage and synovial fluid and will be painful, as after any serious injury to the knee.

Treatment. Fracture into the joint is excluded by a skiagram. The treatment of a fractured tibial spine is considered on page 4491.

An anæsthetic should be given, and the limb put in plaster which should include the thigh and foot. The knee should be extended at 160 degrees and the foot placed at a right angle with the leg. The patient is allowed to get about with crutches and with a patten on the opposite shoe. This plaster should remain on for three months. After that time, faradism should be employed for the quadriceps and active exercises for the knee. Stiffness is likely to be present for at least another eight weeks.

This treatment will result in a good knee in a number of patients

under the age of thirty, but in others there will be a partly flail knee, some having periodic distension of the joint with effusion.

If this treatment fails, an apparatus of the knee-cage type, with a lock to limit full extension, may be employed. Operative repair of a torn crucial ligament causing a flail knee with severe functional defect has been carried out.

The operation of *reconstruction of ruptured crucial ligaments* is difficult. Although some good results are reported, it must be considered still to be on its trial and should certainly *not* be advised unless adequate treatment on the lines suggested has been tried and failed. The principles of the operative reconstruction are: (1) Large exposure of the joint as for arthroplasty (see page 4343 and fig. 2352). The "split patella" approach should be avoided. (2) A strip of fascia, such as the ilio-tibial band, is passed through drill holes in the femur and tibia, to replace the anterior crucial ligament. (3) The fascia is pulled tight with the knee at 160 degrees and fixed extra-articularly, preferably by a bone peg knocked into the drill holes. (4) Fixation in plaster with the knee at 160 degrees for six weeks. (5) Physical treatment with knee support until the knee is strong.

Reconstruction of the posterior crucial ligament is very rarely required, but has been carried out on similar lines.

Arthrodesis. Indications: (1) Tuberculosis. In children this is seldom employed, but in adults it is the routine treatment of tubercle of the knee. (2) Fibrous ankylosis which has been painful, or when there is a tendency to flexion deformity. (3) Disorganisation of a joint, e.g. Charcot's disease. (4) Flail knee joint complicating paralysis, such as anterior poliomyelitis. Most surgeons order a caliper splint but others practise this operation.

When the operation is carried out for tuberculosis, the object is two-fold: (*a*) to remove the diseased area, and (*b*) to produce bony ankylosis.

When the operation is performed for other causes, bony ankylosis is the sole object; consequently, in cases of tuberculosis a careful dissection of synovial membrane is necessary, whereas in the other cases if bony surfaces are brought into apposition the object will be achieved.

Technique. A tourniquet is applied, and the knee is placed over sand-bags. A U-shaped incision is employed, extending from above the adductor tubercle vertically downwards crossing the front of the tibia over the insertion of the infrapatellar ligament, and upwards to above the external condyle. In a tuberculous case, any sinuses should be excised when the skin incision is made. The skin flap is dissected upwards, and the capsule and ligamentum patellæ are divided in the

same line as the skin incision and turned upwards. If the operation is being carried out for tuberculous disease, the cartilage is removed from the patella with a saw, or the patella is excised, and the synovial membrane dissected out in one piece from the suprapatellar pouch. The semilunar cartilages and crucial ligaments are removed and the synovial membrane dissected from the sides of the joint. The leg is pushed backwards so that the condyles of the femur rest on the tibia. With a saw, the lower end of the femur is removed. If there is little destruction of cartilage and bone, it may not be necessary to remove more than one-third of the condyles, but it is essential that the disease should be eradicated and that the saw-cut should be in the same plane as the original joint line. It is often necessary to excise the anterior

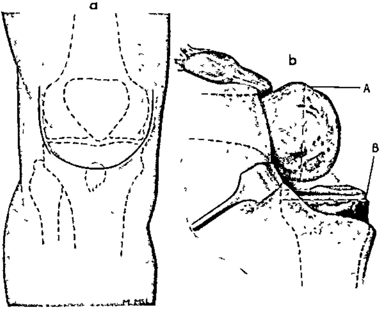


Fig. 2350.—Excision of the Knee Joint.
The skin incision is indicated in Fig a. Fig. b shows A and B, the usual lines of section of femur and tibia respectively.

portion of cartilage by a second saw-cut in the long axis of the bone. The tibia is then brought out into the wound and a thin slice removed from the upper surface. If tuberculous foci extend into the shaft, they can be gouged out or more bone can be cut away. The femur and tibia are separated and synovial membrane is dissected from the back of the joint. The leg is then extended and the divided surfaces of femur and tibia placed in apposition to test if the limb is straight. It is advisable that the thigh and leg should be straight or flexed only a few degrees. The femur and tibia are then fixed together by bone pegs $\frac{1}{8}$-inch in diameter or by thin steel pins, these being driven in through the tibia into the femur in a cross fashion. It is often easier to do this through incisions below the large one already made. It is most important that the tibia and femur should be kept

firmly together while these pins are driven home. The wound, which is made neater by trimming away superfluous capsule and skin, is then closed. The dressing is applied, the tourniquet removed, and the limb fixed in plaster-of-Paris, including the foot.

Some surgeons cut the bones so that the lower surface of the femur is rounded and the upper surface of the tibia concave. This prevents the tibia from slipping back on the femur, but the latter will not occur if pegs or pins are used. If it is considered advisable to employ a drainage-tube for forty-eight hours, it is probably wiser not to place the limb in

Fig. 2351.—Lateral and antero-posterior X-ray photographs of a knee which had been excised for osteo-arthritis three years previously.

plaster-of-Paris but on a Thomas splint. If this method of fixation is employed, the posterior half of the limb can be placed in a shell of plaster and a 4-lb. weight extension used to keep the limb still. Whatever form of fixation is employed, the limb should be raised in bed so that the weight of the leg tends to keep the tibia against the femur. Some surgeons advocate that the pelvis should be included in the plaster. After two to three weeks, the stitches are removed and a plaster-cast is applied from the top of the thigh, including the foot, preferably under an anæsthetic. It is advisable that the patient should remain recumbent for twelve weeks. The plaster is then removed, and an X-ray

photograph taken to ensure that bony union is secure before the patient is allowed to walk.

Arthroplasty of the knee. Before contemplating this operation it should be realised that a stiff knee due to bony ankylosis in a good position performs excellent function. If arthroplasty is carried out, it is essential that after the operation the joint should be painless and stable. The majority of surgeons prefer to convert fibrous ankylosis into bony ankylosis rather than risk an arthroplasty, which may do

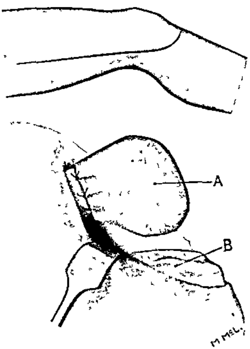


Fig 2352.—ARTHROPLASTY OF THE KNEE.
Upper fig. shows an incision which enables the joint to be exposed and a fascial flap cut from the outer side of the thigh
Lower fig. shows A, the remodelled end of the femur covered with the fascial flap and B, the upper end of the tibia.

little beyond returning the limb to the condition which obtained prior to operation (fig. 2352).

This operation has been practised for nearly forty years, but stable knees with a good range of movement were seldom reported until 1920 when Putti recorded 10 cases: the average age of these patients was 22; the largest range of movement obtained was 100 degrees, the smallest 50, and the average 82.

Technique. The incision used is a long antero-lateral one extending forwards across the front of the leg below the tibial tubercle. The tibial tubercle is detached with the infrapatellar ligament. Care should be taken to preserve ligamentous structures if this is possible. The joint is exposed and the ends of the femur and tibia shaped. The *lower end of the femur is remodelled so that it is similar to the end of a* normal femur, the groove between the condyles being well deepened.

The transverse diameter of the condyles is preserved but the antero-posterior diameter is decreased. Some surgeons aim at a V-shaped lower end of the femur, both in the antero-posterior and lateral planes. Part of the patella may have to be cut away, but it should never be completely removed. The spine of the tibia is made sharp. From the upper part of the lateral incision, fascia lata is cut, one sheet being fixed round the lower end of the femur and another piece over the top of the tibia. No patellar flap is used. If the extensor apparatus appears short, the quadriceps tendon is lengthened by the Z method. The wound is closed. and the leg and thigh are placed in a plaster gutter splint, semi-flexed with a 10-lb. extension applied to the leg. After two weeks the plaster is removed and the knee suspended to an overhead frame with a strap and pulley. In six weeks the patient walks with a caliper, but does frequent exercises. At the end of three months, function should be good.

Synovectomy. This operation is indicated in cases of chronic arthritis of non-suppurative type when there is a persistent large effusion associated with thickening of the synovial membrane. In this type of osteo-arthritis of the knee, there is generally some affection of articular cartilage and underlying bone. but the latter does not form such a prominent feature of the pathological changes as does the synovial thickening. Great improvement in the condition of many knees results from synovectomy but others return to the condition that was present prior to the operation. Experience is not yet sufficient to be dogmatic as to which cases are likely to improve.

Technique. A large incision is necessary. A long lateral incision curving forward over the tibia below the tibial tubercle is suitable, or a half ellipse with the concavity looking inwards. A half ellipse with the concavity looking outwards is undesirable, as sloughing of the flap may occur from lack of blood supply. The tibial tubercle is removed and the lateral portion of the capsule incised so as to turn up the extensor apparatus. The synovial membrane is dissected out in one sheet if possible. care being taken to remove all membrane from the supra-patellar pouch. The semilunar cartilages, the crucial ligaments and the posterior portion of the knee joint are not touched. The suprapatellar pouch is diminished in size by catgut stitches, the capsule closed laterally, and the tibial tubercle fixed back in position. The limb is placed in a gutter plaster splint for two weeks, after which time movements can be commenced. Active movement should be encouraged as soon as the patient is capable of performing it. Manipulation to break down adhesions under an anæsthetic is not desirable.

The operations for fractured patella and for other conditions of the knee joint, including lateral dislocation of the patella, are described in Vol. II, page 3390.

ANKLE JOINT

Arthrotomy is required:

(1) For removal of loose bodies from the ankle joint (such as a separated portion of articular cartilage and bone); and

(2) For suppurative arthritis.

The ankle joint can be approached from the front from either the inner or the outer side by incisions placed in front of the malleoli. Whenever possible, the outer incision is to be preferred. This extends along the anterior border of the lower quarter of the fibula lateral to the peroneus tertius. The tendon of this muscle is retracted medially, and the capsule of the joint is incised from above downwards. If sufficient exposure of the joint is not obtained, the anterior part of the capsule should be raised from the tibia. After closure of the wound it is important that the foot should be placed in plaster at a right angle to the leg.

When suppurative arthritis is proved by aspiration of the joint, the incisions are made where the distension is most obvious. If possible, drainage is provided posteriorly by an incision made on each side of the tendo Achillis. Anterior drainage is not satisfactory as the tendons are likely to fall over the incision in the capsule and thus prevent efficient drainage. The foot should be immobilised at right angles to the leg.

Arthrodesis. Indications:

(1) Traumatic arthritis, particularly associated with malunion of fractures of the ankle joint;

(2) Fibrous ankylosis which is painful;

(3) Ankylosis in faulty position.

Technique. The outer anterior incision 4 inches long is used. The tendons are drawn medially and the joint exposed. The articular cartilage is removed from the upper surface of the astragalus, from the lower surface of the tibia, and from the malleoli (see fig. 2353). It is then found that the astragalus is too loose in the mortice; it is therefore advisable to perform an osteotomy of one or both malleoli so that they can be pushed inwards and outwards to fit snugly against the astragalus. The position of the foot is then tested, as it is desirable to arrange the bones of the ankle joint so that the foot is in a few degrees of equinus. The wound is closed, and the leg and foot are placed in plaster. The plaster is changed at the end of two weeks when a tightly-fitting

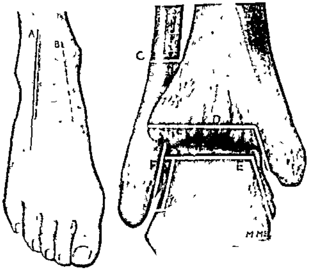


Fig. 2353.—Arthrodesis of the Ankle

A. Incision.
B. Additional incision if necessary.
C. Osteotomy line of fibula (often required)
D. Line of dividing tibia.
E. Line of division of astragalus.
F. Line of division of fibula.

cast is made, with a walking stirrup. This is retained for three months.

When the operation is carried out for ankylosis in faulty position, a wedge-shaped portion of bone is removed with the thick end of the wedge forward.

Arthrodesis of the ankle joint may be performed by driving a bone graft transversely through the fibula, the tibio-astragaloid joint line and the internal malleolus.

Arthroplasty. The functional value of an ankylosed ankle joint in good position is so great that arthrodesis is always preferable to arthroplasty. The possibility of an arthroplasty producing a stable and painless joint is so small that the operation is not advised.

JOINTS OF THE FOOT

In cases of paralysis, particularly infantile paralysis, stabilising operations on the foot are of great value when the foot is flail. They serve an equally good purpose when the foot is drawn into valgus or varus owing to paralysis of one or more groups of muscles. These operations should not be carried out on very young children owing to the interference with the growth of the foot and because further recovery of the muscles may occur. Experience has shown that, in cases of paralysis, arthrodesis of one joint only (such as the astragalo-scaphoid) does not prove satisfactory.

The best results are probably obtained by triple arthrodesis (Dunn's operation). In some cases an operation on the tarsus is of value in cases of dropped foot, and a number of surgeons employ astragalectomy (Whitman's operation) for calcaneo-valgus and other deformities of the foot.

Triple Arthrodesis of the Foot (*Dunn's operation*). This is indicated particularly in cases of flail foot and deformities due to partial paralysis of the foot. Some surgeons employ it for almost any deformity of the foot and in spastic deformities, but it is not the operation of choice in cases of pes cavus (see Vol. II, page 3356).

Technique. A tourniquet is employed, and the inner side of the foot is laid on a sand-bag.

The original skin incision employed was from in front and above the external malleolus to the dorsal surface of the base of the 5th metatarsal bone. However, most surgeons prefer to use a flap, the convex surface downwards; this extends from behind the external malleolus downwards and forwards and then across the dorsum of the foot. The flap is turned up, the extensor brevis digitorum is exposed, its origin from the os calcis is separated, and the muscle pushed forwards. The calcaneo-cuboid joint is exposed; with a thin osteotome the articular surface and a small piece of bone are removed from the front of the

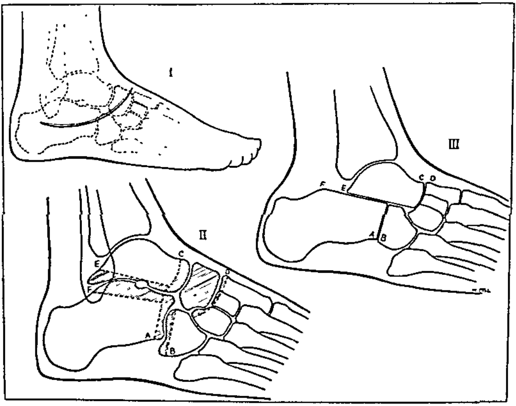


Fig. 2354.—TRIPLE ARTHRODESIS (STABILISATION) OF THE FOOT (*after Dunn*).

I shows line of skin incision.

II shows lines of bone section. A and B are cut first, C and D next, and then F and E.

III, the foot has been fitted together and displaced backwards.

The shortening of the foot depends on the amount of bone removed from the os calcis and cuboid. The amount of backward displacement of the foot depends on the amount of bone removed from the inner side of the foot.

os calcis and the back of the cuboid. The amount of bone thus removed will determine the *total shortening of the foot.*

With a periosteal elevator, the tissues are separated from the head of the astragalus and scaphoid. The anterior tibial group of tendons is retracted inwards. With a gouge, the articular cartilage and a small strip of bone are removed from the front of the astragalus. With the same gouge, the articular cartilage and a small piece of bone are removed from the proximal portion of the three cuneiform bones. This will make it possible to remove the scaphoid and the divided portion of the cuneiform bones. The removal of the scaphoid may be somewhat difficult owing to the attachment of the spring ligament and the insertion of the tibialis posticus. There should be a gap now between the bare surface of the head of the astragalus and the bases of the cuneiform bones. If these do not appear to fit, more bone should be removed until the depression in the cuneiform bones corresponds to the shape of the neck of the astragalus. The interosseous ligament is cleared from between the astragalus and os calcis so as to expose the joint surfaces. These are removed with a thin-bladed osteotome, both from the lower surface of the astragalus and from the upper surface of the os calcis. It is important that these bones should fit together, and allowance must be made for the deformity which was present before the operation.

The foot is then displaced backwards at the subastragaloid joint and is examined to see if it is square. The extensor brevis is stitched back and the wound closed. Plenty of cotton wool is employed in the dressing before the plaster-of-Paris cast is applied: this should extend from the knee and include all the foot. At the end of two weeks the plaster is removed, the stitches taken out, and a more closely-fitting plaster is applied, this is kept on for three months. If the foot is not square when the stitches are removed, an anæsthetic must be employed in order to put the foot in satisfactory position in the second plaster-cast. It should be noted that: (1) The ankle joint is not opened; (2) the shortening of the foot depends on the amount of bone removed from the os calcis and cuboid; and (3) the displacement of the foot backwards depends on the amount of bone removed from the inner side of the foot.

In valgus deformity when the peronei are active, it is usually advisable to transfer the tendons of the peronei to the inner side of the heel or of the tendo Achillis. This should not be done at the same time as the stabilisation, but can be carried out a month after that operation.

Drop foot operation (Lambrinudi). This consists in an arthrodesis of the subastragaloid joint with the formation of a natural bone block. The operation is indicated for any degree of drop foot due to paralysis

of the dorsiflexors when there is an associated varus or valgus deformity. The gastrocnemius muscle should be functioning.

Technique. A tourniquet is applied, and the foot is placed on a sandbag with the outer side facing the operator. The incision is along the posterior border of the fibula round the external malleolus extending forward to the centre of the foot over the metatarsus. The skin and soft parts are dissected forward so that the ankle is exposed, but the ligaments of the ankle joint are left intact. The astragalo-scaphoid joint is exposed and opened. A knife is carried under the neck of the astragalus, and the interosseous ligament between the astragalus and the os calcis is divided. The subastragaloid joint is freely opened and the forepart of the foot displaced inwards. The articular cartilage is removed from the upper surface of the os calcis and from the lower surface of the astragalus. A notch is cut in the postero-inferior aspect of the scaphoid.

Fig 2355.—Drop foot operation (*Lambrinudi*).

I Line A B indicates line of section of the astragalus The proposed notch in the scaphoid is indicated. II shows effect of operation The astragalus is tilted forwards so that it is locked against the scaphoid. The divided area A B now looks downwards. The head and neck have been transferred to form a block behind the astragalus.

The neck of the astragalus is then divided obliquely as is shown in figure 2355. The top of the neck of the astragalus is then fitted into the notch in the scaphoid. The foot is now placed so that it is just below a right angle to the leg; this will tilt the astragalus forward so that there is a gap between the back of the astragalus and the upper surface of the os calcis. This gap is filled in by the piece of bone, which formed the head of the astragalus, after the articular cartilage has been removed from it. The wound is closed, and plaster-casts are applied in a similar way to that employed after Dunn's operation.

Astragalo-scaphoid Arthrodesis. This operation is employed in cases of spasmodic flat foot, when there is arthritis in the joint between astragalus and scaphoid, and for arthritis if the joint is painful. Sometimes fixation is more readily achieved if the calcaneo-cuboid joint is arthrodesed at the same time.

An incision 3 inches long is made along the inner border of the foot with the centre over the joint. The tibialis anticus muscle is retracted,

the joint is defined, and the articular cartilage removed from the head of the astragalus and back of the scaphoid. The foot is adducted so that the surfaces come in contact. If there is a gap when the foot is

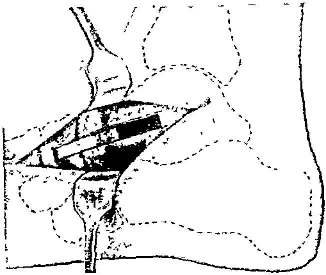


Fig. 2356.—Astragalo-scaphoid arthrodesis. The inner surface of the joint has been exposed. A graft has been cut from the inner surface of the neck of the astragalus and slid forward and inlaid into the scaphoid and astragalus.

placed in the required position, the calcaneo-cuboid joint must be fixed through a separate incision.

A small graft of bone, 1 inch long by a $\frac{1}{4}$-inch, is cut from the inner side of the neck of the astragalus and fixed to the inner side of the scaphoid and astragalus to keep them in the required position.

After closure of the wound the limb is put in plaster until a skiagram shows that bony union is firm. This may take three months.

Operations for hallux valgus are described in Vol. II, page 3348.

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CHAPTER III

Tumours of Bone

A. Simple Tumours

Simple tumours are Osteoma, Chondroma, and Fibroma.

Osteoma

A *compact osteoma* grows on bones developed from membrane; it is a sessile tumour occurring on the skull, and is frequently called an *ivory exostosis* owing to its density being compared to ivory. It is usually single and most commonly grows slowly on the frontal and parietal bones. It is not attached to overlying structures but is adherent to the bone from which it arises. This growth may be found in the frontal sinus, in the walls of the external auditory meatus, or in the roof of the orbit. An osteoma occurring in one of these situations is liable to grow to remarkable dimensions, destroying the surrounding tissues and even encroaching on the cranial cavity. Pressure may be caused on the frontal lobe of the brain, and the eye may be destroyed by a tumour in the frontal sinus or orbit. This growth does not undergo malignant change, but after a number of years a portion may become separated and fall off owing to strangulation of its own blood supply.

Treatment. The removal of a compact osteoma is difficult owing to its density. Removal is only advocated when symptoms, such as deafness—as might be caused by such a growth in the external auditory meatus—necessitate operative interference. If the base of the osteoma can be located, this should be drilled in a number of places and the tumour then be removed with a mallet and chisel.

The cancellous osteoma (*exostosis*) is common and is met with at the ends of long bones. Its formation occurs before the epiphysis has joined the diaphysis; in the first place it consists of cartilage only, so that it is often called an *ossifying chondroma*. Such tumours are most commonly found at the lower end of the femur (fig. 2357), the upper end of the tibia, and the lower end of the radius. One bone only may be affected, but frequently a number of bones are found to have this tumour at their growing ends. The exostosis is usually pedunculated and remains capped with a layer of cartilage. It ceases to grow when

the epiphysis becomes fused with the diaphysis. It is usual to find that a bursa has formed between the cartilage cap and the surrounding tissues. When situated around the neck of the femur, the tumour tends to be of an irregular shape, often having a broad base, and in this situation it may grow to a considerable size (see fig. 2358).

Symptoms. Osteomata themselves are painless, and patients seek advice owing to the presence of the swelling, its increase in size, or because it gets in the way. The tumour seldom presses on nerves, but it may interfere with the movements of the joint or the smooth working

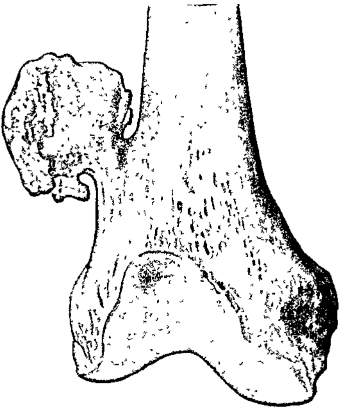

Fig. 2357.—PEDUNCULATED EXOSTOSIS OF FEMUR. IT IS HERE SHOWN COVERED WITH A CARTILAGE CAP.
(*Museum, King's College Hospital.*)

M MCLARTY

of a muscle passing over it. The bursa may increase in size and be painful if the part is knocked.

Treatment. Parents often ask for these growths to be removed from their child without their having caused any symptoms, and the removal under this circumstance is quite justifiable; likewise, removal is advocated if any of the symptoms previously described are present. If the tumour is not found until adult life and is then causing no inconvenience, there is no reason to advise its removal as malignant change does not occur.

Operation. A tourniquet is used if possible. An incision is made in

the line of the bone over the tumour, the muscles are separated and the growth exposed. Dissection is carried out until the pedicle is defined. The periosteum is divided with a knife around the base of the pedicle and pushed aside for a short distance. The pedicle is then divided with a chisel so that the contour of the bone is reduced to its normal size. The tumour and bursa are then removed, the wound closed, and the limb bandaged firmly. As a rule, this operation is simple, and

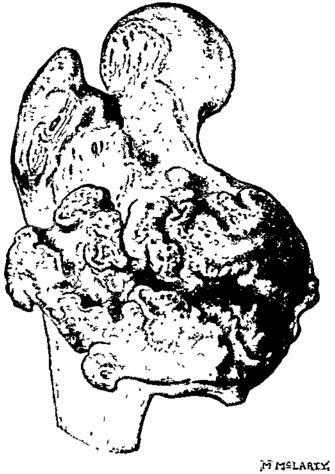

Fig 2358.—A large sessile osteoma of the upper end of the femur. The surface is rough and partly covered by cartilage. On section the tissue is cancellous bone.
(*Museum, King's College Hospital*)

difficulty only arises when the swelling is large and situated in an area which is not easy to approach. This is particularly so if there is no pedicle and if the growth occurs in a situation such as the upper end of the femur.

Subungual exostosis is a tumour growing from a distal phalanx, usually that of the big toe. Although it is possibly an osteoma, chronic irritation from the boot may be a factor in its origin. It usually grows to the size of a pea and appears between the nail and the nail-bed on the inner side of the big toe. Occasionally it is seen in the outer side

of the little toe under the nail. Ulceration may occur, and infected granulation tissue then forms around the tumour.

The treatment consists in removal of the nail and exostosis. In view of the fact that a normal nail does not always grow after this operation on the big toe, it is advocated that the terminal phalanx should be excised with the nail-bed. Such an operation is only suitable in the absence of infection around the tumour.

Multiple exostoses (*diaphysial aclasis*) is the name given to a condition affecting the ends of a number of long bones. The patient is short in stature, and the end of each bone affected is enlarged by knob-like projections. The cause of the condition is not known, but it appears that the ends of the bones are deformed owing to the modelling process, normally carried out by the sheath of periosteum, being in abeyance.

Treatment is generally not required.

CHONDROMA

Although certain characteristics are common to all chondromata, they must be considered in three categories: (1) Multiple tumours of the long bones of the hand and foot. (2) Single tumour of a long bone. (3) Single tumour of the thorax or pelvis. Rarely, a chondroma is found in the skull, usually in the region of the ethmoid bone. When occurring in the skull, symptoms of a cerebral tumour may be produced. A chondroma growing from a vertebra is occasionally seen.

Chondromata are usually encapsuled by fibrous tissue. The cartilaginous mass grows slowly and is generally lobulated. Calcification occurs especially in the fibrous septa, and the matrix between the cells may undergo mucoid or calcareous degeneration.

(1) *Multiple chondromata* of the hand and foot are probably a type of dyschondroplasia. These tumours are seen on the phalanges, metacarpal and metatarsal bones in both children and adults. In this situation there may be a single tumour or there may be a large number. The growth arises from the centre of the shaft, often near the epiphysial plate, and expands the bone. Some appear to be centrally placed, while others seem to protrude on one side of the bone, usually near the joint. The single centrally-placed tumour of a " short long bone " is probably more akin to the single tumour of the femur or tibia than a manifestation of dyschondroplasia.

The symptoms produced are due to displacement of surrounding tissues, to disability from the size of the tumour, or to the occurrence of a pathological fracture. These growths never become malignant. They do not give a well-defined shadow in the skiagr... although frequently

the line of demarcation between the tumour and bone is well defined. The destruction of the bone is seen, and such areas as are calcified show up clearly. If a portion of the chondroma ossifies, this produces a characteristic picture, and this occurs more often in a single tumour of one of the small bones of the hand or foot. Hence such a growth may be more akin to the cancellous osteoma.

The differential diagnosis is easy when the tumours are multiple.

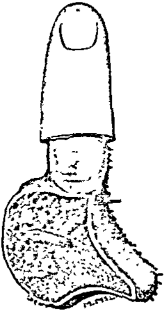

Fig 2359.—Specimen showing a chondroma of the first phalanx

(*Museum, King's College Hospital.*)

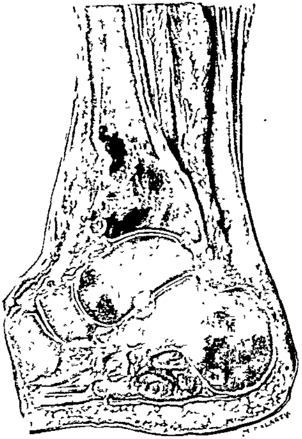

Fig 2360.—Vertical section of a leg removed for a recurrent chondroma of the tibia. A man of forty-five had a tumour excised from the lower end of the tibia. The microscopic section showed it to be a chondroma. Within two years it recurred and the leg was amputated. The section showed chondromatous tissue and blood, but there was no evidence of malignancy. He is alive nearly ten years after the amputation.

(*Museum, King's College Hospital.*)

When only one swelling is present, difficulty in the diagnosis may arise, but it should be easy to determine that the swelling is in connection with the bone; thus ganglion and tendon-sheath tumours are excluded. Inflammatory conditions of a small bone seldom affect only a portion of the shaft. The skiagram usually shows destruction of bone and

opaque areas due to calcification. Tumour substance is not visible. A giant-cell tumour is rare in these small bones, and presents somewhat similar signs and X-ray appearances. In this case expansion of the bone is usually evident, whereas in a chondroma the X-ray appearance suggests that a piece of the bone has been punched out. Fibrocystic disease of a metacarpal has similar characteristics, and a pathological fracture may occur in this condition also. The area of the cyst is less opaque than in a chondroma.

Treatment. When the tumour is single it should be removed by shelling it out from its capsule and splinting the finger. If it is not thoroughly removed it is liable to recur, particularly if it is of soft consistency. Operative treatment is equally indicated if a pathological fracture has occurred.

In cases of *multiple chondromata*, operation is only advised for the removal of a growth which is producing symptoms such as pressure on a nerve or great deformity.

(2) *The single chondroma* of a *long* bone arises in most cases near the cartilage separating the shaft from the epiphysis, but cartilaginous tumours are occasionally found in such situations as the lower third of the tibia. This type of neoplasm possibly originates from islets of cartilage which have failed to ossify in the normal ossification of the bone. It is known that these growths occur in those who have had rickets as children. They are most frequent in young adults in the lower ends of the femur and humerus. The tumour grows slowly, undergoes mucoid degeneration and frequently becomes sarcomatous.

The single chondroma is rare, and it is difficult to determine in some cases if it has arisen as a simple tumour and become malignant, or has arisen in the first place as a sarcoma and undergone cartilaginous degeneration, a condition termed chondrosarcoma.

The symptoms produced are those of pain in the region of the swelling, and the signs those of a bony tumour. The skiagram shows destruction of bone where the growth has originated ; there is no new bone formation as a rule, and the tumour does not ossify. The differential diagnosis is from other bony tumours such as giant-celled myeloma and sarcoma.

Treatment. The patient is advised that it is essential for a correct diagnosis to be made before carrying out treatment and that this can only be achieved by means of a biopsy. The pathologist's assistance is required to determine whether the tumour is simple or malignant. This task is often difficult. Those cases in which there is only cartilaginous or sarcomatous tissue are straightforward. However, experience shows that if the surgeon has any doubt as to whether the tumour is malignant

or not at the time of the biopsy, the pathologist often has a similar doubt on examining the section.

Some surgeons consider that the tumour becomes malignant if it is not already so; hence they advise radical treatment as soon as the diagnosis of a chondroma of a long bone, such as the femur, is made. This indicates that such surgeons do not recognise a simple chondroma of a large long bone, but consider cartilaginous tumours at the end of such a bone to be sarcomatous. This seems drastic in cases in which there is no sign of malignancy, but is doubtless erring on the right side when there is any doubt as to malignancy.

Local removal is advocated when cartilaginous tissue only is found. Post-operative X-ray therapy is ordered by any surgeon who considers that there is doubt about the diagnosis, either at the time of the operation or from the pathological examination. If recurrence occurs, the condition should be treated as a sarcoma. When a pathological fracture has occurred, and in certain situations, local removal may involve excision of two or more inches of a long bone, such as the femur or humerus. Fixation of the bone by a bone graft is not advocated when doubt exists as to the nature of the tumour. Briefly:

(*a*) When there is no proof of malignancy at the time of diagnosis, local removal is advocated.

(*b*) If local removal is impossible, amputation is advised at a convenient place above the growth. Treatment by X-ray therapy may be of value in this type of case, should amputation be refused.

(*c*) If malignant change is present, the case is treated as a sarcoma.

(3) *Single chondroma of pelvis or thorax.* When chondromata occur on the ribs or in the pelvis, they may grow to an enormous size. In appearance they are lobulated and pearly in colour. The larger the tumour, the larger are the lobulations. The symptoms produced are those of pressure, particularly in the pelvis. The removal of a tumour larger than a child's head has often been carried out, but the possibility of its removal depends on the position from which it arises and its relationship to large vessels and viscera. These neoplasms may grow to large proportions and remain simple, but undoubtedly malignant changes may occur.

FIBROMA

A fibroma of bone is rare except in the jaw, when it is termed fibrous epulis. A fibroma of a long bone arises from the periosteum and produces the signs of a nodular swelling fixed to the bone. It is unusual for pain to be produced, and the patient seeks treatment on account of the lump. There are no changes found on X-ray examina-

tion. The tumour should be removed and a microscopic section made to ensure that it is not an early fibrosarcoma. No recurrence will occur after removal of a simple fibroma of the periosteum.

B. MYELOMATA

In this group of tumours are to be considered:

(1) Benign giant-celled tumour, or the solitary myeloma which is often termed osteoclastoma.

(2) Multiple myelomata.

(3) Plasmacytoma: (*a*) single, (*b*) multiple.

BENIGN GIANT-CELLED TUMOUR

This is the only tumour of this group that can be said to occur with any frequency and it is probable that no more than twenty of these cases are diagnosed each year in London. The age incidence is between twenty and thirty, the neoplasm seldom occurring before twenty and rarely after forty; females are affected somewhat more commonly than males. The ends of the bone are involved, and in the epiphysial rather than in the metaphysial area. The commonest positions in which the tumour is found are the lower end of the femur and radius and the upper end of the tibia, but it may occur in all bones of the body at times—the skull, the spine and the sacrum, the clavicle, and the small bones of the hand and foot. There is almost invariably a history of injury which is followed after some months by pain and later by the formation of a swelling. There is a great tendency for the size of the tumour to increase. Pathological fracture occurs in 14 per cent of benign giant-celled tumours.

The clinical findings necessarily depend on the size of the growth. If the patient seeks treatment early, note will be taken of the history—the sequence of trauma, pain, and the formation of a swelling. The physical signs may be limited to enlargement of the end of a bone accompanied by slight tenderness. As the swelling increases, enlarged veins may be present and it may be possible to determine that the end of the bone is expanded more on one side than on the other. The swelling may feel firm but not very hard, and egg-shell crackling may be palpable owing to the thin plaques of bone present in the capsule. A very vascular tumour of some size may pulsate. At other times, the first symptom may be a fracture, or the patient will have known that a swelling was present but has not sought treatment until fracture occurred.

The X-ray appearance is that of a defect of the end of the bone;

there is expansion, usually excentric with a multicystic appearance. As a rule, there are well-formed trabeculæ. The cortex of the bone appears perforated. and thin plaques of bone may be visible on the surface of the tumour.

Examination of a specimen reveals that the central defect is essentially at the end of the bone. The tumour having started in the medulla extends outwards, and as the compact tissue at the end of the bone is thin and the periosteal defence poor, it may push aside the soft tissues. There is usually a well-defined edge across the medullary cavity down the shaft, and in the opposite direction the spread is limited by the articular cartilage. The tumour will not penetrate this and will only extend into the joint round the edge of the articular cartilage, or when a fracture has occurred into the joint, but neither of these occurrences is frequent. The trabeculæ are well defined, and the tumour tissue is reddish-brown. Often liquid blood and maroon-coloured areas are visible. Rarely, the tumour has a more cheesy appearance with small areas of hæmorrhage in it; to this rare type of tumour the name of "white myeloma" is sometimes given. The microscopic appearance is well known, the outstanding feature being a typical giant cell with its fifteen to a hundred nuclei which stain so readily.

The diagnosis is not often in doubt, probably because the radiological appearance is so characteristic. Doubt is likely to arise when the tumour appears in an atypical position such as the spine, the pelvis, a rib or a small bone. When there is doubt as to the diagnosis, a biopsy is advised. The question of biopsy of bone tumours is discussed subsequently under Sarcoma. At the time of biopsy, it may be possible to make a diagnosis from the macroscopic appearance and to proceed with treatment forthwith, or if there is any doubt, the wound is closed and a diagnosis made from the histology of the tumour substance.

Treatment. This should be by surgical measures. The methods available are:

(1) Removal of the growth, which is usually termed "scraping out" the tumour;

(2) Excision of the tumour;

(3) Amputation.

Treatment by irradiation is discussed on page 4362.

The majority of benign giant-celled tumours are treated satisfactorily by method (1). A tourniquet is employed so that the extent of the growth can be defined and removed by dissection. If fracture has not occurred, it will be possible to leave a portion of the

compact bone on the side which is least expanded. After removal of the tissue substance, many surgeons cauterise the lining with pure carbolic acid. The articular cartilage is generally exposed on its deep surface, and an endeavour should be made to avoid opening the joint.

Fig 2361 —GIANT CELLED MYELOMA OF FEMUR. SKIAGRAM TAKEN IN 1931 PRIOR TO OPERATION. THE DESTRUCTION OF BONE BY THE TUMOUR IS SHOWN AND THE LINE OF FRACTURE BOTH TRANSVERSELY AND INTO THE JOINT IS SEEN.

("*British Journal of Surgery*")

Fig 2362.—ANTERO-POSTERIOR SKIAGRAM TAKEN IN 1933 AFTER RECONSTRUCTION. THE LOWER END OF THE FEMUR WITH BOTH CONDYLES CONTAINING THE TUMOUR WAS EXCISED. THE STUMP OF FEMUR WAS IMPLANTED INTO THE TIBIA AND FIXED BY TWO OBLIQUELY PLACED BONE PEGS AND THE PATELLA. FIRM UNION OCCURRED; THE PATIENT HAD 2¾ INCHES OF SHORTENING IN THE LIMB AND COULD WALK AS MUCH AS SHE WISHED.

("*British Journal of Surgery.*")

The cavity left can be filled with bone grafts taken from another bone. It is better to use a few grafts the size of a lead pencil rather than to fill up the cavity with bone chips. Splinting is required after the operation.

When a pathological fracture has occurred or when the swelling is large so that the whole of the end of the bone is expanded, it may seem unlikely that it will be possible to remove the tumour, provide stability

for the bone and leave a satisfactory joint. Although it is wise to take the optimistic view of the effect of the first suggested method of treatment, this may be impossible, particularly at the lower end of the femur. Resection of a portion of the bone with some reconstruction operation, generally ankylosing the joint, may be of value and save amputation.

When there has been gross destruction of over 3 inches of the lower end of the femur or of the upper end of the tibia, amputation may be required. Reconstruction is more likely to be possible in the radius or humerus.

The operator should take infinite pains to remove all the tumour substance, as it seems probable that cases of recurrence only occur after operation if there has been imperfect removal.

The insertion of any form of radium into these tumours is not advised. It appears that it has either no effect or else tends to increase the growth of the tumour.

X-ray therapy has been employed in recent years both alone and in association with surgical treatment. A number of surgeons state that the giant-celled tumour is not sensitive to deep X-ray therapy. However, there is no doubt that if a surgical measure such as partial removal of the tumour has been employed, after-treatment by deep X-ray therapy produces a satisfactory result. I have operated on a giant-celled tumour of the sacrum, on one in the innominate bone of a boy aged nine, and also on a large growth of the vertebral end of a rib involving the bodies of two vertebræ. In none of these three cases was it possible to remove all the tumour substance, and post-operative deep X-ray therapy was employed. The serial skiagrams showed the sclerosis of new-formed bone as the tumour substance disappeared; there has been no recurrence of the growth of these three tumours.

The prognosis is good if surgical removal is complete and if, when incomplete, X-ray therapy is employed. The formation of metastases does not occur.

MULTIPLE MYELOMATA

These occur between the ages of forty and seventy; they are rare and very malignant. Each tumour arises from marrow and there are multiple lesions. Most commonly the flat bones are affected first—the sternum, ribs, vertebræ, skull and pelvis. Pain is a prominent feature. Bence-Jones bodies are present in 65 per cent of cases and the remainder of the cases have otherwise similar clinical features. The patients usually seek treatment because of a pathological fracture, which occurs in 60 per cent of the cases. A large swelling on the sternum or skull may

be the cause of the patient seeking advice. The X-ray appearance is a clear punched-out area in the bone. Examination of the growth shows bone destruction, and the tumour tissue, which bleeds readily, is surrounded by a bony shell. The marrow is replaced by greyish or reddish material. The microscopic appearance resembles that of a Ewing's tumour which is discussed under Sarcoma, but the cytology is less uniform. Plasma cells and lymphocytes are present in large numbers.

It is characteristic of this condition that spread occurs to other bones but seldom to the liver, spleen or lungs. The patients usually suffer from bronchitis and emphysema, and the blood count shows a secondary anæmia. It is typical for the kidneys to show nephritis with degeneration of the tubules and the presence of calcium in the convoluted tubules. The treatment of the condition is unsatisfactory; X-ray therapy is usually employed, and this irradiation produces a characteristic effect in that the tumours melt away, but soon reappear.

PLASMACYTOMA

This is a rare growth found in the shaft of long bones, particularly in the humerus and the femur. As a rule, there are no symptoms of the condition until a pathological fracture occurs through the tumour. The skiagram will show destruction of the bone, generally for two inches, with expansion and a clear area. The tumour substance has the appearance of blood clot. The microscopic appearance suggests a mass of plasma cells. Blood-corpuscles are present in certain areas. Lymphocytes may be seen but not to the extent that they are seen in myelomata.

When the condition is suspected, other skiagrams are taken to exclude multiple myelomata, and the urine is examined to ensure the absence of Bence-Jones bodies. A biopsy will show the microscopic appearance. The treatment consists in the removal of all the tumour tissue and the approximation of the ends of the bones with an intramedullary bone graft. Unfortunately, the bone around the tumour seldom has much reaction and, although the tumour may not recur, the bone graft may absorb and leave an un-united bone. There is no tendency to the formation of metastases in the solitary plasmacytoma.

Multiple tumours of the plasmacytoma type are probably an entity and a form of multiple myelomata. The urine is normal. The diagnosis must rest on the histological examination of a tumour.

C. PRIMARY MALIGNANT TUMOURS

SARCOMATA

(1) Osteogenic sarcoma.
(2) Ewing's sarcoma.
(3) Extra-periosteal fibrosarcoma.

OSTEOGENIC SARCOMA

This name is applied to the common primary malignant bone tumour. Text-book classifications are derived from the presumed area of origin or from the predominance of one type of tissue in the growth.

Osteogenic sarcoma is most common between the ages of ten and thirty, and is rare after the age of fifty, so that it is essentially an affection of youth. The tumour is found most frequently at the lower end of the femur and at the upper end of the tibia: the upper end of the humerus, the ilium, the upper end of the femur and the shaft of the tibia are less common sites. The metaphysis is the site in the long bone which is most commonly attacked.

There is a definite history of trauma in many cases: a few of these neoplasms arise in a bone affected with osteitis deformans (Paget's disease of bone).

majority of cases whatever treatment is carried out. Metastases in the lungs are generally first shown by pleural effusion. The spread is by the blood stream, but it is unusual in this type of tumour to find metastases in other bones.

Diagnosis. The problem of diagnosis is more difficult in the early stages, and at this time is very important. The history of pain and the

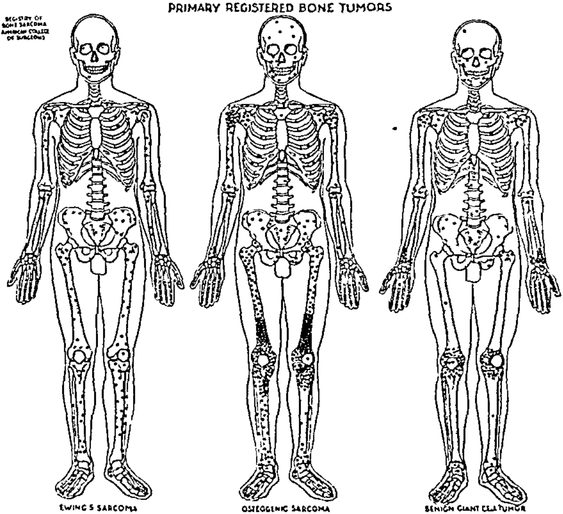

Fig. 2363.—Diagram to illustrate sites of tumours recorded by Registry of Bone Sarcoma. (*American College of Surgeons.*)

onset of a tumour with the signs already described will bring under consideration a number of lesions. No one will neglect to have an X-ray photograph. Unfortunately, in the early stages the X-ray picture is seldom characteristic. Often it is noticeable that there is some change in the bone with a less definite outline of compact tissue and medulla, both of which appear fluffy. One often feels that the skiagram is bad, but this is constantly seen in the early stages of sarcoma. At this time there may be a thin layer of new bone formation

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There is a definite history of trauma in many cases; a few of these neoplasms arise in a bone affected with osteitis deformans (Paget's disease of bone).

Pain is usually the first symptom. A few patients seek treatment because a swelling is present. Sometimes, in the case of sarcoma of the femur or tibia, the patient has noticed a swollen knee joint.

The tumour in the early stages is felt as a swelling on one side of the bone; it is usually tender and there may be enlargement of the subcutaneous veins. Some of these sarcomata feel hard, but when destruction is a prominent feature (osteolytic sarcoma) the swelling feels soft and often spongy. If the latter contains a lot of blood it may pulsate, but the other forms of sarcoma do not show this sign. Effusion into the neighbouring joint is common when the tumour is near the articular cartilage, but there is no thickening of the joint. When the growth is large, its edges are well defined, and owing to the stretching or destruction of muscles, function becomes impaired. The patient's general health is affected sooner or later, generally before secondary deposits are present. This is shown by anæmia, loss of flesh, and pallor, particularly of the face.

Pathological fracture is uncommon, occurring in probably fewer than 10 per cent of cases. It is most likely to be seen in the lower quarter of the femur and below the neck of the humerus.

Dissemination is inevitable without treatment, and occurs in the

majority of cases whatever treatment is carried out. Metastases in the lungs are generally first shown by pleural effusion. The spread is by the blood stream, but it is unusual in this type of tumour to find metastases in other bones.

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PRIMARY REGISTERED BONE TUMORS

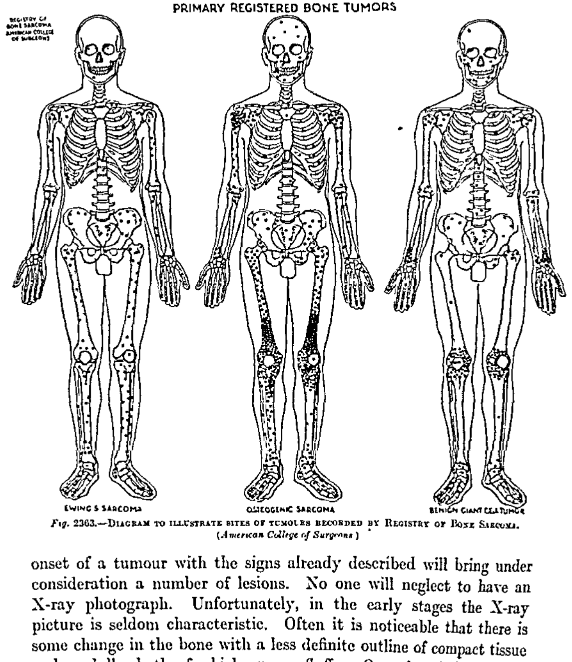

Fig. 2363.—DIAGRAM TO ILLUSTRATE SITES OF TUMOURS RECORDED BY REGISTRY OF BONE SARCOMA. (*American College of Surgeons.*)

onset of a tumour with the signs already described will bring under consideration a number of lesions. No one will neglect to have an X-ray photograph. Unfortunately, in the early stages the X-ray picture is seldom characteristic. Often it is noticeable that there is some change in the bone with a less definite outline of compact tissue and medulla, both of which appear fluffy. One often feels that the skiagram is bad, but this is constantly seen in the early stages of sarcoma. At this time there may be a thin layer of new bone formation

on the surface of the bone, the new bone being parallel to the shaft. A Wassermann reaction should be carried out, and if strongly positive it is obviously in favour of the bony change being a gumma. Syphilitic osteitis, i.e. a diffuse gummatous condition, is not likely to cause difficulty in diagnosis. A subperiosteal hæmatoma which has ossified or traumatic myositis ossificans may have to be considered. More frequently. low-grade osteomyelitis causes difficulty in diagnosis from an early sarcoma. In this connection, a leucocyte count may be of assistance.

At a later stage. a spindle-shaped swelling is often present or a large swelling on one side of the bone, and a differential diagnosis is one of interest rather than of great difficulty. Giant-celled tumour, cyst,

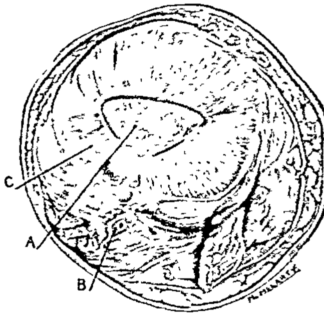

Fig. 2364.—A TRANSVERSE SECTION OF THE LEG SHOWING AN OSTEOGENIC SARCOMA.

A. Tibia. B. Fibula. C. The caseous striæ at right angles to the shaft of the tibia.

The history is interesting. A boy of nineteen years had a tumour which was thought to be non-malignant and was excised in 1919. A bone graft was inserted. The tibia united, and five years later he sought treatment for the swelling caused by the growth. He died two years after an amputation.

(*Museum, King's College Hospital.*)

and gumma are generally under consideration. The X-ray appearance at this time is more characteristic. The outline of the swelling is usually visible as a " soft tissue " swelling. There is a small lip of new bone formation under the periosteum at the edges of the tumour, and there is destruction of compact tissue and erosion of medulla. Osteogenic sarcoma will show spicules of bone at right angles to the long axis of the bone; these are lines of ossification which are present in fewer than 20 per cent of cases altogether. and seldom occur in small tumours.

The certain diagnostic method is *biopsy*—the removal and pathological examination of a portion of the tumour. This is carried out by the majority of surgeons in this country as a means of conclusive diagnosis in order that the utmost may be done in the treatment of the condition. The advantage of this method of diagnosis is not purely to

satisfy the surgeon's mind that the patient has a tumour (which even at that time may be inoperable) but to ensure that he is not dealing with a less malignant condition. When possible, a tourniquet should be used and a specimen of reasonable size should be removed, avoiding blood-vessels. The capsule of the tumour, for such usually exists, should be closed after the portion for examination has been removed. The wound should then be closed. The value of frozen section is probably negligible and it is advised that the surgeon should carry out no operative procedure beyond the biopsy at this time. The pathologist should be given the portion of tumour and afforded every opportunity to carry out his investigations with efficient fixation and staining. Those who are against biopsy state that dissemination occurs owing to incision into the tumour ; there does not appear to be any proof of this occurrence if it is carried out with due care. Further, it is stated that valuable information is not always obtained from the microscopic section ; this is most likely to be the case when frozen sections are examined or the piece of material presented to the pathologist is either minute or consists of œdematous material from around the tumour instead of a portion of tumour substance. Biopsy should be an essential part of the diagnosis. At times undoubtedly the surgeon will at the operation of biopsy find an inflammatory and not a neoplastic condition which he will recognise from the macroscopic appearance ; this will obviously be to the satisfaction of the patient as well as of himself.

Pathology. This tumour spreads slowly through the compact tissue whilst it spreads up and down the medulla. The periosteum appears to be stretched, and some time elapses before the tumour substance penetrates it and starts to invade the soft parts. Eventually the skin may be thinned and ulcerated, the mass fungating and discharging. It is characteristic of the osteogenic sarcoma that some new bone is formed, and that the growth is of varying consistency (the osteolytic soft and the sclerosing firm), whereas the innocent giant-celled tumour destroys bone.

The characteristic histological picture displays the presence of spindle cells. These are small or large and there are often polyhedral cells. The giant cells which are present are not numerous, and are smaller and have fewer nuclei than those of the giant-celled tumour. The intercellular matrix varies in different types of tissue to such an extent that these tumours have been known as chondro-, fibro-, osteo- and myxo-sarcomata. When there is gross bone destruction, the condition is well named osteolytic. The treatment of osteogenic sarcoma is considered after the description of Ewing's tumour.

EWING'S TUMOUR

This tumour represents 15 per cent of all sarcomata. It is essentially a condition of the young adult. It has been recorded at the age of four and a half, but the majority of cases occur between ten and twenty-five and seldom over forty years of age. Males suffer twice as frequently as females. A history of trauma is present in one-third of the cases.

It is a tumour of the mid-shaft area of bone, the epiphysis never being attacked primarily. The bones affected in order of frequency are the tibia, femur, humerus, fibula and ilium. Growth occurs rapidly.

The first symptom is pain, and the severity of this varies. In the early stage it is often intermittent, but later persistent and severe. Intermittent pyrexia is present in many cases and pain is usually severe during the period of fever. A leucocytosis of over 10,000 is often found. The tumour is on the shaft of the bone, feels firm and elastic, and is tender, particularly during an attack of fever. The interesting feature is that periodic decrease in size may occur. Pathological fracture is very rare.

The X-ray appearance in the early stage shows the cortex of the bone to be thickened, chiefly owing to the new bone formation parallel with the shaft of the bone. Sun-ray spicules may be present as the tumour grows. Later, a patchy destruction of bone is usually seen.

The morbid anatomy is well known. The shaft of the bone is expanded by diffuse infiltration. This leads to widening and increased density of the compact tissue and to mottling of the marrow. New bone formation occurs early and is usually parallel to the long axis of the bone, but sometimes presents an ill-defined sun-ray appearance. This formation of new bone often appears to precede destruction of the normal bony elements and is secondary to infiltration of the bone by the tumour. It arises in the subperiosteal plane, or intra-cortically. Possibly this has a relationship to lymph channels. Its presence certainly accounts for the rarity of pathological fracture. The tumour material consists of a soft necrotic mass, not unlike brain tissue in appearance. The medullary cavity is diminished, not so much by growth as by new bone formation.

Histologically, the tumour consists of small round and polyhedral cells with round or oval nuclei. They are packed closely together and often in clumps. Osteoclast giant cells are found around areas of necrotic bone. The cytoplasm is scanty and nearly stainless. In some tumours fibrous trabeculæ are seen. There is a variation in vascularity, the

blood being in spaces between tumour substance with embryonic vessel walls only.

The metastases occur in the lungs, lymph nodes and bones, particularly the skull, spine, scapula and clavicle. Secondary deposits may occur two and a half months after the onset of symptoms and usually within one year. Sometimes patients do not seek advice until

Fig 2365.—SARCOMA OF FEMUR—PROBABLY TO BE CLASSIFIED AS A FIBROSARCOMA, WHICH FOLLOWED MULTILOCULAR FIBROCYSTIC DISEASE OF THE SAME AREA. THE PATIENT WAS FORTY WHEN HE HAD A SPONTANEOUS FRACTURE THROUGH THE CYSTIC AREA. THIS OCCURRED A SECOND TIME ONE YEAR LATER. AFTER ANOTHER YEAR HE NOTICED A MASS ON THE OUTER SIDE OF THE THIGH. THE LIMB WAS DISARTICULATED AT THE HIP JOINT. HE WAS ALIVE AND WELL SIX YEARS LATER.

(*Museum, King's College Hospital*)

swellings are present in more than one bone. It is not known in what tissue this tumour originates. Some consider it to be a primary growth of bone-marrow cells and not a tumour of a true bony tissue—hence the name *endothelial myeloma* by which it is also known.

Diagnosis. Skiagrams and Wassermann reaction should be aids to the diagnosis. Confusion in the early stages is likely to arise between types of osteomyelitis and Ewing's tumour. In the later stages the

clinical picture and X-ray appearance should cause little difficulty, as neither resembles other simple or malignant tumours at all closely.

Enlargement of the shaft of a long bone occurs in osteomyelitis of low-grade virulence and in syphilitic osteitis. Differential diagnosis from the former is made more difficult by Ewing's tumour causing periodic pyrexia and leucocytosis. The pain of chronic osteomyelitis is less severe and, although it may be intermittent, does not tend to increase weekly. The X-ray appearance should aid the diagnosis, for the new bone and areas of rarefaction are more irregular in the inflammatory condition, and sequestra may be present. In the rare sclerosing osteitis which Garré described, the tibia is frequently affected and the history is one of long standing. The severe pain which the patient may have had at the onset seldom continues, and a chronic "bone ache" persists.

Irradiation may be employed as a means to diagnosis. This is referred to under Treatment. If more than one tumour in bone is present when the patient first seeks advice, the diagnosis from multiple myelomata may cause difficulty.

PERIOSTEAL FIBROSARCOMA

This is a tumour of periosteum, which may become large but does not cause destruction of bone. Pain is present. but is not of the same intensity as in bone-destroying growths.

The swelling is hard, attached to the bone. well defined, and usually surrounds the shaft. The soft tissue shadow of the tumour is visible in the skiagram. and as the neoplasm grows there may be a reaction over the bone shown by a thin layer of subperiosteal new bone parallel to the shaft.

TREATMENT AND PROGNOSIS OF SARCOMATA OF BONE

A biopsy is advised prior to the treatment. for the reasons already stated. The chest is examined by X-rays for evidence of metastasis. The methods of treatment available are:

(1) Local removal of the tumour with or without resection of a length of shaft of the bone.

(2) Amputation.

Either of these can be combined with:

(3) Irradiation by high voltage X-ray therapy, or

(4) Injection of Coley's fluid. sometimes called toxin treatment. The irradiation and toxin treatment can be combined.

(5) Radium treatment.

The treatment advised for *osteogenic sarcoma* is amputation. When possible this should be planned so as to remove the whole length of the affected bone and the whole length of muscles covering the tumour. Thus, a mid-thigh amputation is employed for a tumour of the tibia, and a disarticulation at the hip joint for a femoral growth. The lungs should be treated by irradiation at regular intervals. In America and a few British clinics, Coley's fluid is employed after amputation. Local removal combined with other treatment is not advised, and partial removal is likely to cause rapid spread. Treatment of the growth with radium generally makes it grow more rapidly, and irradiation is of no benefit, especially in the sclerosing type of growth. When cartilage forms a large part of the osteogenic sarcoma, irradiation is sometimes effective in treatment. When operation is contra-indicated owing to local or metastatic conditions, Coley's fluid is advised. The younger the patient, the worse is the prognosis. In the report of the American Bone Sarcoma Registry published in 1935, there were 74 patients with osteogenic sarcoma alive after 5 years. Of these 39 were treated by operation alone and 35 by operation combined with irradiation or Coley's fluid or both.

In the treatment of *Ewing's tumour*, it has been found that irradiation diminishes the size of the growth. It does not effect a permanent cure. Probably it is of advantage to irradiate the tumour prior to surgical intervention, and this is advised. Amputation is considered to provide a better chance of survival than local resection. Surgery with irradiation probably produces 10 per cent of survivors for over five years, but the average post-operative life after all forms of treatment is only sixteen months. Many cases do not seek treatment until symptoms have been present for a year. The American Bone Sarcoma Registry reported 10 survivors after 5 years out of 126 cases, all of whom were treated by surgical measures (7 amputations, 3 excisions of the tumour). Of the 7 amputations, 5 received both toxin treatment and irradiation.

The periosteal fibrosarcoma should be treated by surgical measures —excision in the early stages and amputation later. The tumour is of low-grade malignancy.

Treatment by Coley's fluid has been less successful in this country than in his own hands. His own statistics are of interest:

Of 126 *sarcomata of long bones* 56 survived 5 years—osteogenic sarcoma 35, Ewing's tumour 21 :

$$\left.\begin{array}{l}\text{Amputation was employed in } 35\\ \text{Local resection } \quad ,, \quad\quad ,, \quad 21\end{array}\right\}\text{ Of these 47 received toxin treatment.}$$

CHARACTERISTICS OF CERTAIN BONE TUMOURS

Type.	Age (years)	Sex.	Site.	Bones.*	History.	Path. Fracture.	Metastases.	Radiographic appearance.
Giant-celled Tumour	20–30	F>M	Epiphysial area	Femur: lower end Tibia: upper end Radius: lower end	Trauma ⟶pain ⟶tumour	13%	None	Multicystic expansion Trabeculation
Osteogenic Sarcoma	10–30	M>F	Metaphysial area	Femur: lower end Tibia: upper end Humerus: upper end	Trauma ⟶pain ⟶tumour	8%	+ (Lungs)	Early—*fluffy* appearance Late—spindle swelling *Erosion of cortex*—radiating ossification
Ewing's Tumour	10–25	M>F 2:1	Centre of diaphysis	Tibia, Femur, Humerus } shaft	Pain Tumour Rapid growth	Rare	+ (Lungs, glands, bones)	Patchy destruction Slight new bone formation
Metastatic Carcinoma (solitary)	40–60+	M=F	Variable	Femur: upper $\frac{1}{3}$ Humerus: upper $\frac{1}{4}$	Pain ⟶ fracture ⟶tumour	33%	+ (Other bones, pelvis, spine)	Destruction of cortex Cystic expansion Slight new bone formation

* Commonest bones affected in order of frequency.

time is thus much increased. If two distinct sets of X-ray apparatus are available, some time can be saved in the taking of the antero-posterior and lateral views.

Technique. The patient is anæsthetised and placed upon an orthopædic table fitted with perineal post and traction apparatus for the feet. Traction is applied with the feet about 12 inches apart and the legs rolled slightly inwards.

The direction of the neck of the femur is estimated in the following manner:

A point 1 cm. below the middle of Poupart's ligament is marked on the skin by a small piece of lead. This marks the highest point of the head of the femur. Another point is marked by lead about 8 cms. below the tip of the trochanter. The line joining these two marks indicates the direction of the femoral neck. Antero-posterior and lateral skiagrams are now taken and the accuracy of reduction and position of the neck, relative to the lead marks, is checked. If correct, a small incision is made at the base of the trochanter and a Kirschner wire drilled into the neck, using the lead marks as a guide. It is best to insert three wires in all, the second and third being above and below the first, but in the same horizontal plane. The length of wire to be inserted must be carefully checked beforehand, by measurement from the normal femur in the manner described under the "open" method.

Another set of X-ray pictures is taken, and the position of the wires observed, in both the antero-posterior and the lateral views. A correctly-placed wire should be exactly in the centre of the neck and head, both in the vertical and in the horizontal planes. (Should none be in a sufficiently good position, the wires must be extracted and re-inserted.)

The wire in the best position is left *in situ* and the others are withdrawn.

A Smith-Petersen nail, of the requisite length, is now threaded over the guide and hammered home with the hollow punch, care being taken not to drive the guide in with it. The guide is withdrawn, traction is released, and the neck is gently impacted into the head with the impactor. The function of impaction is to close the gap between the fragments, and it should not be too vigorously employed. The nail is driven home once more and the small incision sutured.

Finally, a third set of X-ray films is taken to check the position of the fracture and nail. Should either prove to be unsatisfactory, the nail must be withdrawn with the extractor and the whole operation repeated. (Withdrawal of the fully inserted nail is often extremely

For these cases, two methods are applicable:

(1) *Plaster-of-Paris Spica.*

Suitable cases:

(a) *Sub-capital Fractures*:

(i) Some cases of adduction fractures unsuitable for operation.

(ii) Abduction fractures.

(b) *Basal Fractures.*

(c) *Per-trochanteric fractures with no displacement.*

"*Whitman's Abduction Treatment" for (a) and (b).*

Until the Smith-Petersen operation became fashionable this was the standard method of dealing with fractures in the region of the hip joint. It is claimed that bony union is obtained in about 66 per cent of cases of all ages.

The method, though usually considered in relation to cervical fractures, is also applicable to basal fractures.

The *principles* are simple: (i) Reduction of deformity by manual traction. (ii) Locking of the fragments by full abduction and internal rotation of the leg. (This is brought about partly by the tension of the anterior part of the capsule, and partly by leverage of the femoral neck against the upper lip of the acetabulum.) (iii) Fixation of the leg in the position of abduction and internal rotation by means of a plaster spica.

Details. The patient is anæsthetised on an orthopædic table. Stockinette is applied smoothly to cover the whole of the injured leg and the body as high as the axillæ, the skin being previously powdered. Each leg is held by an assistant and equal traction is applied, the patellæ being rolled inwards. The surgeon applies pressure over the region of the trochanter. Both legs are then abducted as fully as possible, *care being taken that the pelvis is maintained square with the body.*

Accuracy of reduction may be checked by measurements, or by X ray examination.

Sheet wadding is applied, paying special attention to the padding of bony prominences, such as the sacrum, trochanter, spinous processes, anterior spines, and malleoli. It is better to use felt over these prominences if the patient is thin. Plaster bandages are used to construct a spica, which must extend from the axilla on the non-affected side, including the pelvis and the whole of the affected limb. The knee is flexed to about 30 degrees.

A well-applied spica should fulfil the following conditions:

(i) Affected limb :	Full abduction.
	Full extension.
	Slight internal rotation, maintained by flexion of the knee.
	Foot at right angles.
(ii) Sound limb :	Free. Full flexion should be permitted.

After-Treatment.

(i) Skiagrams to check position of fragments.

(ii) Prevention of sores by nursing patient part-time on back, then on face, and then on sides.

(iii) Raising *head* of bed to avoid congestion.

Duration. A period of *three* months in the spica will be required for a cervical fracture, and rather less for a basal fracture. Following this, a month in bed, during which time massage and exercises are given, and finally a period of ambulatory treatment for a further two or three months, during which time a weight-bearing caliper is worn.

Difficulties of abduction methods. The construction of a plaster spica which will stand up to the strain and stress of three months' nursing is *no mean undertaking.* Some 20–30 bandages (6–8 inches wide) are necessary. Sores are apt to develop, in spite of every care. The nursing of such a case is heavy, and lifting will require at least four helpers.

When plaster is employed for a *sub-capital abduction fracture,* a short plaster spica with the leg in " adduction " is made, walking being allowed from an early date.

(2) *Simple Traction.*

The methods of treatment already described are unsuitable for the *aged or infirm.* Nevertheless, a definite line of treatment should be instituted, although the hope of obtaining a firm union by bone is remote, and the best that can be hoped for is a fibrous ankylosis.

The practice of putting the patient to bed with the legs " between sand-bags " is to be condemned. Fixation of the leg in this way merely ensures that whenever the body is moved, movement inevitably takes place at the fracture line, causing considerable pain and discomfort. These patients should be " put up " on a simple weight extension applied either by adhesive strapping, or, better, by a Kirschner wire inserted through the crest of the tibia. Rotation can be controlled in this way. Counter-extension is made by raising the foot of the bed.

The leg is allowed to lie on a Thomas splint, bent at the knee, or on a Braun frame. The foot must be kept at right angles. A weight of 10–15 lb. will be sufficient. The weight extension is continued for about

three weeks, but a skiagram should be taken after a few days, to check the correctness of the weight. Should this be too small, coxa vara will persist, or if too large, coxa valga may result. The patient is then provided with a walking caliper and allowed to get about, at first with crutches, and later with the aid of sticks. The caliper will probably need to be worn permanently.

Basal Fracture

This type of fracture is usually impacted, and therefore little displacement is the rule. Bony union is to be expected.

Two methods of treatment may be adopted: (1) Fixation in a plaster-cast, on the lines of the Whitman method already described; or (2) Treatment on a Thomas or Braun splint by moderate traction, even if the fracture is impacted. Recumbency for about twelve weeks will be required and a walking caliper is advisable for six months afterwards.

Per-trochanteric Fracture

This type is often accompanied by shortening and coxa vara. The lesser trochanter may be separated from the shaft. The mechanism, according to statistics of 207 cases (Stebbing), is that the body weight is suddenly thrown on to the femur when the leg is in *adduction.* Direct blows on the trochanter are rarely causative. This view is contrary to the usual teaching and is not supported by experiments upon the cadaver.

The *treatment* consists of continuous weight extension for a period of 12–14 weeks. Maintenance of internal rotation and abduction are of importance and a walking caliper should be used subsequently.

(Details of weight extension and the prevention of stiffness of the knee are considered under Fractures of the Shaft of the Femur. See page 4481.)

Treatment of Non-union in Fractures of the Femoral Head

Given a case of un-united fracture of the neck of the femur, the question arises, Should anything be done, and if so, what?

The answer to the first part of the question can only be found by study of the individual case. Age, condition, amount of disability, and presence of pain must all be considered. X-ray pictures must be taken to determine the degree of deformity and the condition of the femoral head. If the bone density of the head is similar to that of the shaft, it may be assumed that the head is still living. If the head is dense, it is probably avascular and dead. In the presence of an avascular

or an absorbed " head," operative fixation of the fracture by nailing is obviously useless, and consideration may be given to some form of reconstructive procedure.

Successful reduction and fixation of an un-united fracture has been seen by the author in a middle-aged man, a year after the original injury.

The following *methods of treatment* are available:

(1) *Fixation of the Fracture* (femoral head alive).

(*a*) Skeletal traction in an endeavour to overcome coxa vara.

If successful, (*b*) Fixation of fracture by Smith-Petersen nail.

(i) Open operation in order to freshen bone-ends.

(ii) By " blind " method.

(*c*) Fixation by bone graft.

(2) *Osteotomy* (Sub-trochanteric).

(*a*) *Simple*—in order to restore the normal relationship between the shaft and neck of the bone.

(*b*) *Bifurcation operation.* An oblique osteotomy is made through a 5-inch incision over and below the great trochanter. The shaft is displaced inwards so that it lies partly under the head and partly under the lower border of the acetabulum. This is controlled by direct vision. Fixation is effected by a plaster spica for 3–4 months. Bony union should occur between the shaft, head and trochanteric region.

The latter is the method of choice, as in a simple osteotomy the fibrous union at the site of fracture persists.

(3) *Reconstruction operation* (e.g. Whitman's).

(4) *Arthrodesis of the hip joint.* (This is difficult and liable to failure.)

Separation of the Upper Epiphysis of the Femur

Fractures in the region of the femoral neck are uncommon in children and adolescents, but when they occur the epiphysial line is often involved. Treatment should be on conservative lines either by continuous traction or by reduction and fixation in a plaster spica.

Of different ætiology is the " so-called " " slipped epiphysis " of the upper end of the femur.

The condition occurs in adolescents between the ages of 10–15, i.e. before union of the epiphysis with the neck, which occurs about the 18–20th year. The patient is often of the fat, heavy type, with under-developed genitalia, suggestive of pituitary insufficiency. Enlargement of the sella turcica, as seen in a lateral X-ray picture of the skull, has been recorded.

The history is usually one of slight injury, such as a fall or twist of the leg whilst running. The child may get up and continue to walk or limp about subsequently. In some cases the condition is not discovered for some days, until there is pain, or a limp is noticed by the parents. On examination, there is adduction and external rotation of the affected limb, raising of the trochanter, and shortening of $\frac{1}{4}$-inch to $\frac{1}{2}$-inch. Movements are full except for abduction and internal rotation, which may be greatly limited. *A skiagram is essential for accurate diagnosis.* The lower lip of the epiphysis will be seen projecting below the lower border of the neck, the deformity being similar to that of an (adduction) sub-capital fracture in an adult. A notable feature is the absence of any bony spicule broken from the diaphysis, which is constantly present in slipped epiphyses in other situations (e.g. lower end of radius).

Should the case be of long standing, the displaced epiphysis will have fused with the femoral neck, the result being one form of *adolescent coxa vara.*

Treatment. This may be considered under three headings:

(1) *Within three or four weeks of the injury.*

(*a*) Reduction of the deformity under anæsthesia by manual traction, followed by abduction and fixation in a plaster spica ; or

(*b*) Reduction by continuous traction, exerted over a period of three months, until union is firm. The traction is combined with a gradual increase in abduction and internal rotation.

As the epiphysis is firmly engaged with the femoral neck, forcible traction may do no more than rotate the epiphysis in the acetabulum.

The method of reduction by continuous and gradual traction is much to be preferred.

When complete it may be continued until union is firm, or fixation may be effected by a plaster spica.

(2) *After four weeks* reduction will probably be impossible except by open operation, and fixation of the epiphysis by means of a bone peg or graft.

After-Treatment. Relief from weight-bearing by means of a caliper should be insisted upon for from 3-6 months after the initial period.

(3) *Late cases,* where union has occurred. Sub-trochanteric osteotomy should be performed in order to correct the coxa vara. Some shortening will be permanent. Limitation of movement at the hip joint is usual.

Prognosis. In *early* cases, when reduction and fixation has been satisfactory, the femoral head and neck may be expected to shape

normally. When reduction has been moderate, good function is to be expected for some years, but osteo-arthritis will develop subsequently. Open reduction is usually followed by a completely or partially ankylosed joint.

When reduction has been carried out by forcible manipulation and in some cases of non-reduction, the head will undergo the changes associated with deficient blood supply, and a stiff joint and early fusion of the head and neck will occur.

When reduction is imperfect, the epiphysis will often fuse with the shaft during the first year after the accident.

In *unreduced cases,* coxa vara will develop, and in later life osteo-arthritis is inevitable.

Early fusion of the epiphysis will result in shortening of the limb.

Shaft of the Femur

This group includes:

(1) Sub-trochanteric fractures.

(2) Fractures of the shaft proper.

The majority of cases occur in young adults and children. The type of fracture in adults may be either transverse or oblique, a common variation being the " butterfly " fracture, in which a triangular loose fragment becomes detached from the shaft. In children it is nearly always a long oblique or spiral fracture. Owing to the thick covering of muscles with which the bone is provided, open fracture is rare, but when it does occur, the consequences are likely to be serious owing to difficulty in maintaining accurate alignment during the longer period of union, which may result from: (*a*) Infection of the large hæmatoma and lacerated muscles; (*b*) osteo-myelitis and necrosis of bone; (*c*) delay in union, or non-union; or (*d*) stiffness of knee and ankle.

These fractures are usually accompanied by considerable shock.

Fracture of the Upper Third

The upper fragment is flexed by the ilio-psoas, and abducted and externally rotated by the gluteus medius, obturator internus and allied muscles. Control of the upper fragment is not possible, except by open operation, and it is necessary to remember that alignment must be obtained by bringing the lower fragment into a corresponding position.

Fracture of the Middle and Lower Thirds

Here, apart from the common factor of shortening or overlap, the adductor group is of importance (especially the adductor magnus).

The upper fragment tends to lie on the inner side of the lower fragment and often at an angle with it, the angle being open outwards (i.e. valgus).

Gravity is of considerable importance. Backward angulation of the fracture due to this cause is of frequent occurrence, both in the early and in the later stages of treatment.

Diagnosis is usually easy. The severe pain and shock, marked swelling, mobility, shortening and external rotation of the foot cannot be missed. The only cases likely to present difficulty in diagnosis are those of partial fractures in children, with a minimum of deformity, and these are rare.

X-ray examination *before* reduction of the fracture is desirable, but not always necessary, and may be omitted if not readily accessible. It should *never* be omitted *after* reduction, and in the majority of cases a portable apparatus is essential, because the patient and extension appliances cannot be moved into the X-ray room.

Treatment.

First Aid. Shock should be prevented as far as possible by keeping the patient warm. Ambulance attendants and others should be instructed that on no account must the patient be moved or lifted until a splint, possibly improvised, has been applied. The temporary splint of choice is a Thomas' provided with a large ring which can be slipped over the clothing. Fixed extension is easy to obtain by means of a clove-hitch over the boot, or a skewer thrust between the sole of the patient's foot and that of the boot. The extension is tied firmly to the end of the splint, the ring making counter-extension on the tuber ischii. The use of a Liston splint, so often applied as a first-aid measure, is bad. It is "better than nothing," but does not allow the application of extension which is so essential in the transport of these cases. The Thomas splint is easier to apply and far more effective. On arrival at hospital, the patient's general condition must be noted and treatment of shock, if necessary, should be carried out before the first-aid fixation is removed. A blanket bath or other exposure is to be avoided, as it is essential to keep the patient warm.

Reduction. Accurate reduction of a fractured femur can only be carried out by *traction*, which may be either:

(1) *Rapid.* (*a*) Manual; (*b*) Mechanical (screw-traction apparatus).

(2) *Continuously applied by means of a weight* through: (*a*) Adhesive strapping; (*b*) Skeletal traction appliances.

Manual traction is only applicable to children or adults with poor muscular development. When the method is to be used, it is best to apply the means of fixation of the fracture (i.e. adhesive strap-

ping) to the leg *before* traction is made. It is difficult otherwise to maintain traction and apply the strapping at the same time. When the traction has overcome all overlap, as checked by an assistant with a tape measure, a well-fitting Thomas splint is slipped on and the adhesive plaster tied firmly to the end of the splint. This method of *fixed extension* will maintain the degree of reduction already obtained, but in the event of incomplete reduction, no improvement in position will take place.

Should reduction be found to be incomplete, either by measurement or X-ray examination, some other method must be adopted.

Fixed extension is more suitable for children over the age of four, in whom it is usually easy to obtain complete reduction at the first attempt.

Screw traction should *not* be used for treatment of fractures of the femur, as a general rule. Its chief application is to the tibia, but in certain cases which are to be treated in plaster-of-Paris, the use of screw traction may be indicated.

Adhesive strapping: The chief applications for this method are in: (i) Children; (ii) Poorly-developed adults; and (iii) The later stages of treatment after the removal of skeletal traction.

Its usefulness is limited by: (i) The breaking strain of the material; (ii) Its adhesive power to the skin; and (iii) The amount of pull that may be applied to the skin without the development of sores.

In general, it may be said that 10 lb. is the limit of weight which can be used in conjunction with strapping, and as this weight is *insufficient* to reduce overlap of a fractured femur in a well-developed adult, the method of traction by adhesive strapping is a limited one.

The best type of strapping is *elastoband*—extension bandage (Smith and Nephew). This material is not expansile in the length of the strapping, but will stretch in width and therefore fits the limb.

Skeletal traction. The advantages, method, and sites of application have been considered in a previous section (see page 4395).

The Steinmann pin is recommended. If traction is to be made from the lower end of the femur, the pin should be used in preference to the wire as it is difficult to control the direction of a wire, owing to " whip " in the portion passing through soft tissue.

Site for traction (see fig. 2371).

The upper end of the tibia is usually advised, because it is:

(i) Accessible; (ii) Remote from the knee joint; and (iii) Remote from the hæmatoma surrounding the fracture.

Common sense must be used in the choice of site, but a pin inserted

through the lower end of the femoral shaft has the following obvious advantages: (i) A direct and better control of the lower fragment of femur is obtained. More powerful traction is possible. (ii) The traction is not applied through the ligaments of the knee joint, so that the risk of an *unstable* knee is avoided. (iii) The knee is left free for movement from the first. In spite of assertions to the contrary, the knee joint is *not* easily moved when the pin is placed in the tibia. (iv) Damage to the knee joint is inexcusable. It may be avoided by placing the pin in the lower third of the shaft and *not* immediately above the condyles. (v) Damage to the femoral artery is unlikely to occur if ordinary care is taken.

Direct contra-indications are: (i) Fracture in lower third (pin through site of hæmatoma); and (ii) Local sepsis or potential sepsis (i.e. an open fracture).

Anæsthesia. Deep general anæsthesia is required during the stages of insertion of the pin, manual traction, and adjustment of the splint. It is of great advantage to apply manual traction even if skeletal traction is to be used subsequently, as a large amount of overlap may be reduced when the muscles are completely relaxed. In Continental clinics, local anæsthesia is the routine method, but it seems better to reserve it for special cases in which the administration of a general anæsthetic is inadvisable.

Treatment of Fractures of the Femoral Shaft at different Ages

(1) *Birth injuries* to the femur are unusual, but may result from traction applied to the groin or leg during a breech delivery. The best method of fixation is to flex the thigh acutely on the abdomen and to maintain contact by means of a few turns of flannel bandage. Added support may be obtained, if required, by a moulded splint of metal or plaster, applied to the flexor aspect of the thigh and bandaged into position against the abdominal wall. Traction is not required. Fixation must be maintained until firm union is found upon clinical examination, usually a matter of 3–4 weeks. This method enables the baby to be suckled and his excreta to be attended to with little difficulty.

(2) *Children under five years of age.* The fracture is almost always oblique. The best method of traction is that of Bryant. Adhesive strapping is applied to both legs from groin to ankle. The child is treated on his back, with the lower limbs flexed to a right angle with the trunk. A Balkan beam or other bed frame is fitted to the cot and a cord from the injured leg passed over a pulley on the beam; sufficient weight is attached so that the child's buttocks are just clear of the mattress. The weight of the child's body acting through the site of

fracture is sufficient to bring about reduction. For the purposes of nursing it is convenient to tie the other leg loosely to the beam. Provided the knee of the sound leg can be flexed slightly, no interference with traction will result. The addition of back splints and foot-pieces to the fractured limbs helps the stability of the apparatus.

After four weeks, union will usually be firm enough to dispense with traction. The child should be kept in bed for another four weeks before weight-bearing is allowed, and it is usually advisable to apply a light plaster-cast during this period, for the sake of protection to the soft callus.

(3) *Children over five years of age.* These cases are best treated by "*fixed extension*" applied by means of adhesive strapping and using a Thomas splint of suitable size. The strapping should be applied down each side of the leg, extending from groin to ankle. No provision need be made for knee movements, as full movement will always be obtained at this age, provided accurate alignment has been secured. All overlap can be overcome by manual traction at the time of application of the splint, but should any persist, it is easy to tie a cord to the end of the splint and to apply a weight of 5 to 10 lb. This method of *combined* fixed extension and weight extension is perfectly rational. The "fixed" portion prevents any recurrence of overlap and the weight is used to overcome any that is not already reduced. All that is necessary is to take up any "slack" in the strapping (i.e. see that the ring of the splint is against the tuber ischii) by *daily* adjustments.

An added advantage is that the application of a small weight relieves the pressure of the splint ring against the skin of the buttock and so prevents chafing.

Note. With all extension apparatus a daily inspection is required. Spirit and powder should be "worked in" within the ring and at all pressure points, and care taken to see that the bandage slings on the splint are at the correct tension to prevent angulation. Special attention to the regions of the tuber ischii over the tendo Achillis and heel is advisable.

In from five to six weeks the splint may be removed or, alternatively, after three weeks, when the union is moderately firm, the leg may be put into a plaster-cast, including the pelvis and the foot.

In nearly every case this simple procedure can be carried out *without* an anæsthetic. The method is convenient as the child, once in plaster, can be sent home.

Weight-bearing should not be allowed for eight or nine weeks as a minimum.

(4) *Adolescents and adults.* In the majority of these cases, *skeletal traction* should be used as a routine (see fig. 2411). Counter-traction is

made by raising the foot of the bed 12 to 18 inches. A muscular patient will require a weight of 15 to 20 lb. at the outset, and during the first week X-ray checks should be taken on alternate days. The weight can be adjusted according to the X-ray findings. *Over-extension* must be avoided. At the end of a week, all overlap should be overcome and the

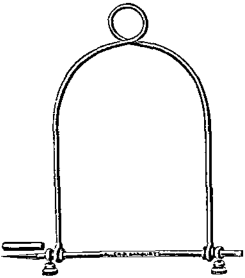

Fig. 2411.—Simple traction pin and stirrup. Note fixation screws to prevent the pin from sliding sideways. The stirrup is free to rotate on the pin, so that the pin does not rotate in the bone

optimum weight for maintenance of the fracture in good position should have been found.

The most useful splint is the Thomas. It should be provided with a hinged knee-piece, as shown in the illustration (fig. 2412). An adhesive strapping extension should be applied to the lower leg, and a small weight (5 lb.) added in the manner shown in the illustration. In either case, the knee should be slightly flexed so that the leg and foot are clear of the extension cord, which is in the line of the femoral shaft.

Having applied traction, the next step is to adjust the slings so that the normal forward bow of the femur is restored. The slings should be fastened with large safety-pins; the "paper clips" so often used are liable to slip gradually, thus allowing angulation to recur. The thigh and leg may be covered with flannel for warmth, and a "tea cosy" forms a suitable covering for the foot. All coverings must be readily removable for daily inspection.

Finally, provision must be made against *foot drop*. The best method is to attach a cord to the sole of the foot by a strip of adhesive plaster, and to pass the cord over a pulley. A small weight (1 lb.) pulls the foot up to a right angle and at the same time allows the patient to exercise the ankle.

Counterpoise. If a Thomas splint is used, the splint and leg

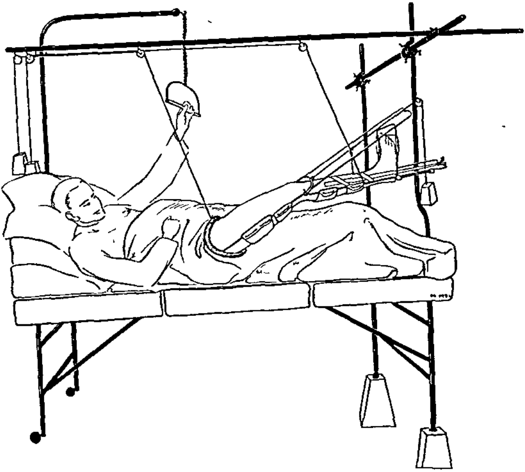

Fig 2412.—This diagram illustrates method of applying traction for fractured shaft of femur on a fracture bed.

Note traction pin in crest of tibia, weights to counterbalance splint and limb, hinged knee piece of Thomas splint, and support to keep foot at right angle. Foot of bed raised on blocks. Divided mattress is employed.

should be slung *clear of the bed* by means of a system of counterpoise weights. Two cords and weights are needed. One passes from the *splint ring over pulleys to the head of the bed. About 5 lb. weight should* be attached. This is enough to counterbalance the upper end of the splint when the patient is lifted for the purposes of nursing. The other cord is attached to the lower end of the splint and will need more weight (10 lb.) to balance the weight of splint and leg, so that it is kept clear of the bed. On no account should the splint be tied directly to the bed-rail.

Knee movements. Lateral movement of the patella is carried out from the commencement.

After four weeks, if union is progressing well, *passive knee movements* may be started. A "string and pulley" arrangement which enables the patient to do this himself is valuable.

Faradic stimulation of the *quadriceps* is a valuable adjunct until the

patient can learn to contract the muscle actively. This should be done for ten-minute periods, several times a day. The services of a masseur are necessary at this stage. The progress of union and position should be checked each fortnight by X-ray examination.

Removal of pin or wire. In the majority of cases, it is quite safe to leave the pin *in situ* for 6–8 weeks. If inspection of the site of the pin shows clean wounds, there is no reason why the pin should not remain in the limb longer. When the skin is removed, skeletal traction should be replaced by an adhesive strapping extension. Two sets should be applied, one set exerting traction in the line of the femur, the other in the line of the tibia—this may be applied when the primary setting is done—being fixed to the movable portion of the splint, and thus allowing knee movements to be continued. The strapping extension should be applied *before* skeletal traction is removed. Should suppuration appear at the site of the pin, it must be removed forthwith.

Usually at the end of 10-12 weeks traction may be relaxed and the splint removed. Some delay in union is common and the decision to remove apparatus must be made upon clinical and X-ray findings.

After-Treatment. Faradism and active exercises designed to strengthen the muscles and to increase the range of knee-flexion must be continued. A weight-bearing caliper must always be provided, and no weight-bearing should be allowed for at least another six months.

Difficulties in treatment.

(1) The surgeon is often asked to see "late" cases, which have been inadequately treated during the "all important" first week. Prolonged skeletal traction or open operation may be required to obtain a satisfactory result.

(2) Correction of *lateral displacement* is sometimes difficult. The use of sorbo-rubber pads, attached to a small clamp and screw which can be fixed to the bar of the Thomas splint, will usually overcome this difficulty. Lateral pressure can be applied by this means at the appropriate site. Lateral displacement seldom leads to such disability as follows unreduced antero-posterior displacement.

(3) Angulation is easy to correct by pads or by adjustment of the slings when there is no overlap.

(4) In cases of *delayed union*, the temptation to relax traction must be resisted. Traction *must be* continued until union is firm.

Delayed union may be brought about by excessive ardour on the part of the masseur or patient, or by over-extension. If sufficient rest and time be given, union will usually occur.

Late Complications.

(1) *Shortening* of more than ½-inch should be regarded as a bad result.

(2) *Stiff Knee*, due to:

(*a*) Prolonged fixation; or (*b*) Excessive callus formation in fractures of the lower third of the shaft. The quadriceps become adherent to the bone. Excessive callus means union in a bad position, and the complication will not occur in a well-aligned fracture.

(3) *Angulation.* This is due to inefficient treatment or to weight-bearing before the callus is consolidated. A badly-fitted caliper will allow it to occur.

(4) *Arthritis in knee and hip* may occur as a result of *malunion;* abnormal and excessive strain is thrown upon these joints.

Indications for Operations.

(1) *Early.* It is difficult to make out a good case for early operation in fractures of the femoral shaft, in view of the excellent results obtainable by skeletal traction. The risks of sepsis, delayed union due to internal fixation by foreign bodies, and the technical difficulties, are great.

Provided asepsis can be assured, however, operative fixation should still have a place for those cases in which skeletal traction has failed to obtain good alignment after ten days. Exposure of the shaft is made through an antero-lateral incision between the vastus externus and rectus muscles. Only the crureus need be incised. Plating is the best method of fixation, and a stout plate provided with eight screw holes should be used.

(2) *Late.* Cases of non-union or malunion may require open operation. *Bone-grafting with or without additional fixation* will probably be needed.

Treatment in Plaster-Cast.

Apart from children, the method has a very limited application owing to the impossibility of maintaining traction and to the prolonged fixation of joints which is inevitable. The method should be used for adults only in those few cases which are uncontrollable by other means. Mental derangement, lunacy, or when prolonged recumbency is undesirable, may be cited as examples. The cast must be applied while the femur is under traction on an orthopædic table, and should include the pelvis and the whole of the injured leg.

Supracondylar Fracture

It is important to realise that the lower fragment will be tilted *backwards* by the pull of the gastrocnemius. The sharp upper end of it may damage the popliteal vessels or nerves. *Genu recurvatum* will result if the deformity is not corrected.

Treatment is by skeletal traction, and the knee must be well *flexed.* A Thomas splint is used, bent at the site of the fracture. A pad behind the site of fracture may help to push the lower fragment into alignment.

Fracture of the Condyles

One condyle may be fractured from the shaft when the knee joint is forced into a varus or valgus position. Tear of the opposite lateral ligament may occur.

Both condyles may be fractured in falls upon the foot from a height. The upper end of the tibia is driven between the condyles like a wedge. The line of fracture is into the knee joint, and much effusion of blood into the joint will be present.

Treatment. (1) Manipulation may be tried. It should consist of traction on the leg by an assistant, while the surgeon exerts pressure on the condyles with his hands. If successful, the joint is fixed in a plaster-cast, extending from buttock to foot. The knee should be straight.

(2) More often, open operation will be required. A long lateral incision is made and the joint emptied of blood. The fragments are manipulated into position with bone levers, and fixed by bolts, screws or plates Gentle knee movements may be started in 3–4 weeks.

In either case after 6-8 weeks a weight-bearing caliper should be worn

Separated Epiphysis

Separation of the lower femoral epiphysis is an uncommon injury, but may occur before the epiphysis joins the shaft at about the twentieth year. The injury is one of hyperextension of the knee joint

Fig 2412.—Skiagram showing slipped epiphysis at lower end of femur. In this case a perfect reduction was obtained by manual traction.

so that the fractured surface of the epiphysis looks backwards (fig. 2413).

Treatment. This should be immediate manipulative replacement under general anæsthesia. Fixation may be in a plaster-cast with the knee flexed 20 degrees or, alternatively, the limb may be placed on a Thomas splint with extension. Should manipulation fail, skeletal traction must be made from the tibia. Knee movements may be started in four weeks, and a caliper should be worn subsequently.

PATELLA

The bone is fractured in two ways:

(1) *By muscular violence.* (Common in middle age.) The fracture is always transverse, about the middle of the bone, but may be nearer the upper or lower pole. It may be a crack, but commonly there is wide separation of the fragments, due to the action of the quadriceps muscles. It is important to realise that the line of fracture invariably extends sideways into the lateral patellar ligaments, which are part

Fig 2414.—(*a*) Illustrates separation of patella fragments with in turning of the aponeurosis. (*b*) Fibrous union joins the fragments in an untreated case.

of the extensor mechanism of the knee. The aponeurosis covering the bone is also torn, and the frayed edges curl in between the bone fragment (fig. 2414*a*), thus preventing bony apposition except by open operation. Fibrous union is certain to occur if the fragments are separated (fig. 2414*b*). The result is an unstable knee joint.

Rupture of the quadriceps tendon may take place instead of fracture of the patella (see also Vol. II, page 3462).

(2) *By direct violence.* This type occurs as a result of a direct blow on the patella. The fracture is stellate, and a minimum of displacement of the fragments is the rule.

Diagnosis. (1) Transverse type.

(*a*) History of having tripped, this being followed by pain. The patient attributes the accident to his subsequent fall. (*b*) Inability to extend the knee joint. (*c*) Great effusion into the joint. (*d*) A gap may be felt between the fragments; this may be masked later by blood clot and effusion. (*e*) X-ray examination.

(2) Stellate type.

The diagnosis is made upon the history of a direct blow, together

with local tenderness and effusion. In the skiagram a *bipartite patella* must not be confused with a stellate fracture.

Treatment.

(1) *Transverse or stellate types, without displacement.* A firm pressure-bandage is applied. The joint is immobilised in full extension on a posterior splint. It is best to mould a plaster slab to the limb, from the buttock to the ankle, but a wooden "Ham splint" forms a useful first-aid method of fixation. The limb is elevated upon a pillow. When swelling and pain have subsided, the patient may walk; after three weeks the splint may be removed daily for active exercises to the knee, but no walking should be attempted without it under six weeks.

(2) *Transverse type with separation of fragments.* The limb is elevated and a pressure-bandage and posterior splint are applied. The skin is carefully prepared for operation, which is usually undertaken four days after the injury.

The patella is exposed by a horse-shoe incision, convexity upwards; the incision should extend well laterally, so that adequate exposure of the lateral patellar ligament is made. The fragments are cleared of blood clot and aponeurosis, and excess blood is gently squeezed out of the joint. The methods of fixation of the fragments available are:

(*a*) A number of catgut stitches are passed through the aponeurosis covering the two fragments of bone and are pulled tight to approximate the fragments. The tear in the lateral part of the capsule is closed by catgut sutures. No suture passes through the bone.

(*b*) Each fragment is drilled vertically or horizontally and a

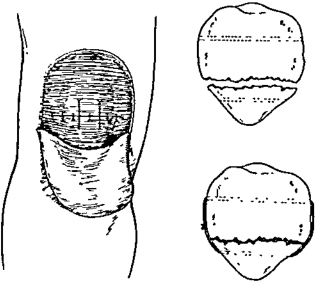

Fig. 2415.—Upper figure shows transverse fracture of patella with line of drill holes when placed horizontally. In lower figure fixation material has been passed and fragments drawn together tightly. Left hand figure depicts suture of aponeurosis and lateral portion of capsule. This may be employed alone, and is always the final stage of the fixation.

"mattress" suture of stout catgut or kangaroo tendon is passed through the holes. When tightened, the fractured surfaces should be in close apposition.

(c) A stitch is passed deep to the aponeurosis, and made to encircle the patella, like a purse-string.

In each case care must be taken that the articular surfaces are in accurate alignment. Careful suture of the layers of aponeurosis on either side and in front of the patella is next made, and the skin incision is then closed.

The first type of suture is suitable when the bone fits together easily and the aponeurosis is thick and takes the stitch well. The second type should be considered as the routine treatment. The stitch round the patella can be employed as an adjunct to either of the above methods or may be used alone. As a rule, it does not hold the transverse fracture well if employed alone.

(3) *Stellate fracture with spread of the fragments.* The operation employed is exposure of the patella, clearance of ragged tags of aponeurosis and encircling of the patella with a purse-string suture of thick catgut.

After-Treatment. A firm bandage and a posterior splint are applied over the dressings and the limb is elevated. The stitches are removed on the tenth day. The splint should be worn for six to eight weeks, and walking may be commenced after three weeks. Faradism to the quadriceps muscles is possible without removing the posterior splint. Active knee-joint movements are started in six weeks.

Complications.

(1) If silver wire is used as a suture material, sepsis and bone atrophy may necessitate its removal.

(2) Re-fracture is not uncommon. The other patella sometimes fractures during the period of convalescence.

(3) Some arthritis and stiffness of the knee is likely, as most of the patients with this fracture are middle-aged.

TIBIA

Fractures of the upper end of the tibia extending into the knee joint are of:

(1) The tibial spine.

(2) The condyles of the tibia.

The Tibial Spine

It is important to be aware of the existence of this injury, and to realise that the diagnosis is not difficult and that a definite line of treatment should be adopted immediately.

It is an "avulsion fracture," produced by violent tension on the anterior crucial ligament. As the latter is tense in extension, the violence is a forced *hyperextension* of the knee. The portion of bone torn up is usually about ½-inch wide, ¾-inch from before backwards, and ¼-inch thick. It is the area of attachment of the anterior crucial ligament. This portion of bone is elevated from its bed, so that it lies just above the level of the surface of the tibial head. The injury may occur in children under ten, but is most frequently seen in men between twenty and thirty. The history is that of a severe wrench. There is an effusion of blood into the joint, and pain at the line of the joint. The knee is locked so that full extension is not obtainable. With little displacement it will be locked at 170 degrees, but commonly at 150 degrees, so that the knee is 30 degrees short of full extension. There is abnormal antero-posterior movement so that the tibia can be displaced forwards on the femur. The antero-posterior skiagram shows a piece of bone in the joint, centrally placed, and this is seen in the lateral view also.

Differential Diagnosis. When there is little displacement, the lesion may be mistaken for a displaced semilunar cartilage owing to the locking. The skiagram will show the bony lesion. In an anterior crucial ligament tear alone, there is no bony block and a normal X-ray picture. In injury to articular surface of femur, tibia or patella, a fragment may be displaced and cause similar symptoms. The history in this type of case may not relate the exact type of violence. Bony block occurs, but laxity of antero-posterior movement is not present unless lateral ligaments have been torn. The X-ray film will show the hollow from which the piece of bone and articular cartilage have been detached.

Treatment. There is some divergence of opinion as to whether every case should be operated on to refix the detached piece of bone, or whether operation should be limited to those cases with considerable (¼-inch) upward displacement.

The *non-operative treatment* consists in manipulating the knee straight under an anæsthetic and fixing it in plaster. For such a manipulation to be a success it implies that the piece of bone is pressed back into its notch and remains there. In view of such an improbability, it is my opinion that this line of treatment should be limited to patients on whom an open operation is contra-indicated, or to those who realise that, if the post-manipulative X-ray photograph shows the displacement still present, an open operation will be necessary.

By *operative treatment*, a perfect reposition and a strong knee are

obtainable, whereas with the best manipulation the piece of bone is left *slightly elevated so that the anterior crucial ligament is looser than* normal. Removal of the fragment of bone is to be condemned.

Procedure. A tourniquet is employed. The knee is flexed 45 degrees from the extended position. The incision, which is nearly

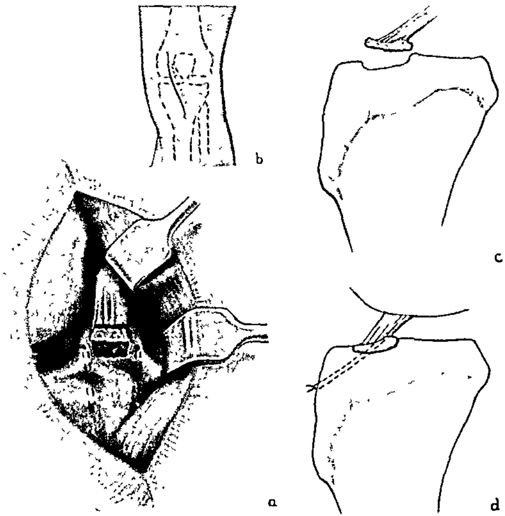

Fig 2416.—FRACTURE OF THE TIBIAL SPINE.

(*a*) Shows the fragment of bone elevated from the upper surface of the tibia. Line of drill holes are indicated.
(*b*) Line of skin incision used for exposure.
(*c*) Lateral view to show how fragment is elevated.
(*d*) Lateral view after replacement and fixation of fragment.

6 inches long, commences above on the inner side of the patella, ½-inch from its lower border, and extends downwards parallel to the inner border of the infra-patellar ligament to just below the tubercle of the tibia. The capsule and synovial membrane are opened in the same line. A retractor is placed on the infra-patellar ligament and, if free access to the front of the joint is not likely to be obtained, the tibial

tubercle is removed with a chisel, flush with the crest of the tibia, and the ligament and patella are retracted outwards. (This is unnecessary in a child.) With a dissector the edges of the fracture are defined and the fragment is carefully elevated. Blood clot and any loose cancellous tissue is removed from the notch. The fragment of bone is fitted into the notch.

Should the assistant elevate the leg, it will be seen that the fragment will leave the notch again.

With a morse drill not larger than $\frac{1}{16}$-inch, two drill holes are made from the anterior surface of the tibia, deep to the normal position of the infra-patellar ligament, obliquely upwards and backwards as shown in figure 2416. Catgut No. 2 threaded on a needle is passed up one hole, through the attachment of the crucial ligament to the fragment of bone and down through the second drill hole (alternatively it can be passed directly through the fragment, but drilling the fragment may split it). The assistant presses the fragment home with a pair of forceps whilst the stitch is tied in front of the tibia. The knee should now be extended to see that the fragment does not move. If this does occur, it shows that the stitches are too loose.

The tibial tubercle is fixed into place with stitches or a nail. The joint and skin are closed. The limb is put in plaster with an extended knee for ten weeks. Weight-bearing is allowed after a month, but no joint movement until the plaster is removed. A window can be cut for faradic stimulation.

The Condyles of the Tibia

The condyles are fractured by forcible abduction or adduction injuries of the knee (fig. 2417). The fracture line, of necessity, runs into the knee joint, and considerable effusion of blood will usually be found. Tearing of the corresponding semilunar cartilage is a frequent complication, particularly when the outer condyle is fractured. It may be displaced, so as to lie between the broken fragment and the fractured surface of the shaft.

Displacement. The triangular portion of condyle is displaced downwards, causing irregularity of the articular surface of the tibia.

Should the fracture remain unreduced, two serious complications are likely to follow: (*a*) Gross osteo-arthritis of the knee, with corresponding diminution in the range of movement; and (*b*) Genu varum, or valgum, according to the condyle involved.

Fracture of both condyles is a rare injury, but when it happens the tibial shaft is forced between them like a wedge.

Treatment. Should great effusion be present in the joint, it may be

wise to rest the leg for a few days on a Thomas splint, bent at the knee, or on a Braun frame. A firm pressure-bandage should be applied to limit the effusion.

Reduction.

(1) *By manipulation.* An anæsthetic is given and the knee strongly abducted, for fracture of the internal condyle. The internal lateral ligament remains attached to the fragments and pulls it upwards into

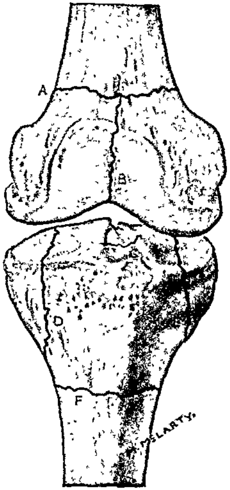

Fig. 2417.—Fractures of condyles of femur and tibia. Lines indicating the types occurring singly. The fracture of a condyle of the tibia may extend more into the centre of the joint than is here shown.

position. Direct pressure on the fragment (by the fingers) may be of assistance. The reverse manœuvre is applied for fractures of the external condyle.

(2) *Should manipulation fail,* a Steinmann pin is driven firmly into the fragment, which is then levered into position.

(3) *Incomplete reduction* should be treated by open operation. The fracture is exposed by a vertical curved incision, blood clot cleared away, and the loose fragment fixed by a couple of bone pegs or a wood screw. Removal of the corresponding semilunar cartilage may be necessary.

Needless to say, exceptional care must be taken that the skin of the operation area is intact, free from blisters, and carefully prepared by a three-day preparation. During the operation the knee joint is opened and the consequences of sepsis made correspondingly serious.

(4) *Fracture of both condyles* necessitates:

(*a*) Traction in the screw-traction apparatus from a pin through the os calcis.

(*b*) Lateral compression to force the displaced fragments into position, by the hands or by the compression clamp.

After-Treatment. The fracture having been reduced, the knee is fixed in a plaster-cast extending from the buttock to the toes. The joint should be in full extension but not over-extended, and care must be taken to avoid genu varum or valgum. Antero-posterior and lateral X-ray pictures are then taken as a check of accurate reduction.

A walking-iron may be applied and the patient allowed to get about after a week. The plaster should remain on for ten weeks.

Should it be decided to treat the case by massage and mobilisation, the cast should be bivalved after four weeks. Great care must be exercised, as the deformity is liable to recur, especially if weight-bearing is allowed too early without adequate support.

If traction fails to reduce the displacement, open operation is advisable. The fragments are aligned correctly and held in place by a metal screw and bolt. This is passed transversely about ½-inch distal to the joint. The advantage of the bolt is that, as it is screwed tight, the fragments are compressed. It is advisable to remove the bolt about eight weeks after the operation.

Shaft of the Tibia

The common site for fracture is in the middle third. Two types occur frequently: (1) The *transverse* fracture, due to direct violence and often associated with a skin wound; a large proportion of these result from motor-cycle accidents in young adults. (2) The *oblique* fracture, due to indirect violence or torsion. If a skin wound exists in this type, it is due to the sharp bony point of the lower fragment being forced outwards and not to the causative violence.

In children, the fracture is almost invariably of the *spiral* type, with little or no displacement. Fracture of the *fibula* is commonly associated. In the transverse type of fracture, the fibula is usually broken at or about the same level as the tibia. In the oblique type, the break in the fibula is 2 or 3 inches higher than the tibial fracture, but fracture of the neck of the fibula is often associated with fracture below the middle of the tibia.

Deformity. In adults, this is often considerable.

(1) *Transverse fracture.* (*a*) *Fibula intact*: little or no shortening; lateral displacement or angulation. (*b*) *Fibula fractured*: shortening and lateral displacement with angulation.

(2) *Oblique fractures.* (*a*) *Fibula intact*: angulation or lateral displacement. (*b*) *Fibula fractured*: shortening, in addition.

(3) *Spiral fractures in children* (*fibula often intact*): deformity usually limited to *slight* shortening and lateral displacement.

Complications.

(1) *Open fracture* is by far the commonest complication in adults. If the skin wound be a mere puncture, as it frequently is, many of these cases can be treated as if they were closed fractures, and run the normal course of a closed fracture. Should sepsis supervene, however, local osteomyelitis with sequestra formation will greatly delay the time of union.

(2) *Comminution* is frequently found in the transverse type due to direct violence. A triangular portion of bone may be detached or a number of smaller fragments may be present. Some may undergo necrosis, if torn from the attached muscle and periosteum.

(3) *Malunion* is seen more commonly than it should be. This may be attributed to faulty reduction, or to inefficient fixation for a sufficiently long period. Removal of the plaster-cast for "massage" before union is firm is another frequent cause.

The most serious cases of malunion are those with angular deformity. Slight shortening is of less importance. Sometimes a large, unsightly mass of callus forms around one of the detached fragments. Its presence is of no consequence except from the cosmetic point of view.

(4) *Non-union* results from: (*a*) Sepsis; (*b*) Over-traction with interposition of soft parts; (*c*) Insufficient splintage; and (*d*) Malposition.

Treatment.

(1) *Children.* Should displacement be present, correction under an anæsthetic by manual manipulation is usually all that is required. It is rare that the need for continuous traction arises. Fixation is by a well-fitting plaster-cast, extending from mid-thigh to the tip of the toes. The *knee should be flexed* 15 degrees, with the foot at right angles. Accuracy of reduction should be checked by antero-posterior and lateral X-ray films taken through the cast.

In small children it is well to protect the heel of the plaster with a pad of felt or to apply a wooden "sole" to the cast, otherwise the plaster will be found soft and cracked after a few hours of play by the child.

In older children a walking-iron may be fixed as soon as the cast is hard. In oblique fractures, however, the child should not bear weight on the leg for a month, as the risk of over-riding of the fracture inside the cast is great.

All splinting may be removed in from 6 to 8 weeks.

Note. It should be an *invariable* rule that *all* cases of recent fracture treated in plaster-of-Paris should be inspected within twelve hours of application of the cast. Better still if they can be admitted to hospital for twenty-four hours. Neglect of this precaution may result in pressure sores, swollen limbs, ischæmia or gangrene, apart from intense pain to the patient.

At the slightest suggestion of swelling or blueness of the extremities, the cast must be split open and the limb elevated. It is important to remember that wadding or bandage beneath the plaster should also be cut.

(2) *Adults.* Three methods are available:

(*a*) Manipulative reduction followed by plaster-cast.

(*b*) Reduction by means of the screw-traction apparatus of Böhler or Watson Jones, followed by plaster-cast.

(*c*) Continuous skeletal traction on a Braun frame for two or three weeks. Later, a plaster-cast.

(*a*) If the case is seen early, before much swelling has appeared, it is occasionally possible to " hitch " the fracture under an anæsthetic, and to fix it immediately in plaster. It is only possible to " hitch " transverse fractures in this way and the method is of limited application.

(*b*) Screw traction is particularly useful in oblique fractures. The essential points in the method are:

(i) The shortening is overcome by mechanical traction, and lateral displacement is corrected by pressure with the hands at the site of the fracture.

(ii) The knee is flexed to a right angle in order to relax the calf muscles. This is an essential step. Counter-traction is made by the bar of the apparatus against the lower part of the thigh, just above the popliteal space.

(iii) When reduction is satisfactory, a plaster-cast is applied and allowed to " set " *before* the traction is released (see Vol. II, figs. 1949 and 1950).

Method. The patient is anæsthetised, and the heel prepared and painted with iodine. A Steinmann pin is inserted through the os calcis, and a stirrup applied. An assistant makes manual traction from the stirrup, while the leg is lifted on to the traction apparatus. The bar for the knee must be well padded with felt or sorbo rubber, and should be adjusted to such a height that the knee, when resting upon it, is flexed nearly to a right angle. The stirrup is attached to the hook of

the traction screw. It is convenient to have a spring balance between stirrup and hook, so that the actual traction may be read off in pounds, but this is not essential. The screw is gradually tightened, and a careful check is kept upon the measurement of each tibia (from the upper end to the internal malleolus. Both legs should be in the same position while the measurement is taken.) If the fracture can be "screened" in the theatre, so much the better.

When all shortening has been overcome, the site of the fracture is massaged in order to remove any œdema, and the subcutaneous surface of the bone is palpated. Any lateral displacement is corrected by pressure with the two hands from either side.

The leg, if hairy, is smeared with vaseline to prevent adhesion of the plaster.

A plaster slab is made, 6 inches wide and of sufficient length to extend from the knee to the toes, as measured along the back of the leg. It is applied directly to the skin, without padding, and bandaged along the calf with smooth turns of flannel bandage. That portion for the foot is now moulded round the heel and cuts are made at the corners to make it lie smoothly. The foot portion should be held by an assistant until hard. The corners may be made quite strong by splitting the layers of plaster and dovetailing them together alternately.

When correctly applied, there should be a strip of skin uncovered by plaster, about 2 inches wide down the front of the leg. A thin layer of wadding is now laid over this gap in the plaster. Finally, two or three plaster bandages are applied in the ordinary way so that the whole leg from knee to foot is encased. When the plaster is set, traction is released and the apparatus removed. The knee is now protected by wadding and the cast continued up to the middle of the thigh. The pin is removed through a small hole in the cast.

The position of the fracture is checked by means of X-rays. When this method is used, the patient may walk in a few days with a walking-iron fixed in the plaster.

Modifications.

(i) It is sometimes recommended that a complete plaster-cast be applied without the preliminary slab and wadding. If this is done, it is *essential* to split the cast immediately along the anterior surface throughout its whole length, as considerable swelling of the limb may occur after screw traction is released.

(ii) Instead of carrying the cast above the knee, a firm hold on the upper fragment may be obtained by inserting a second pin through the upper end of the tibia. In this case both pins are left *in situ* and

incorporated in the plaster. As an alternative to the pin through the os calcis, one may be placed through the lower end of the tibia.

(c) *Continuous traction.* This should be used:

(i) Where screw traction has failed. (In this case the plaster slab is not applied, but the fractured limb is immediately transferred to a Braun frame and continuous traction applied.)

(ii) As an alternative to screw traction.

(iii) Where the fracture is complicated by a large wound or by sepsis.

(iv) In late cases, in which deformity has not been corrected at the outset.

Method. The patient is anæsthetised, a pin is inserted through the os calcis, and a stirrup then applied.

The limb is laid upon a Braun frame and a weight of 10–15 lb. attached to the stirrup. After a few days a set of X-ray films is taken and any necessary adjustment made. Special care is taken that the limb is not over-extended and, when shortening has been overcome, the weight is reduced. Usually in from 3–6 weeks the callus is sufficiently firm to allow the application of a plaster-cast. This should be applied in the manner already described, but the layer of wadding may be replaced by one turn of flannel bandage. The slab should be applied *before* traction is released, the slings on the Braun frame being removed for the purpose. When hard, the limb is lifted clear of the frame, stirrup and pin are removed, and the plaster-cast is completed.

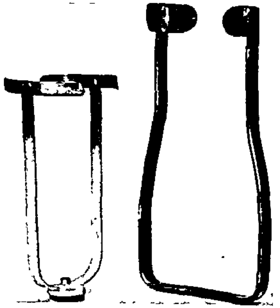

Fig. 2418.—Two types of walking iron or stirrup. The rubber pad is a Phillips rubber heel, attached by a bolt.

Should a wound be present, "an inspection window" may be cut in the plaster.

After-Treatment. The majority of these fractures should be treated by the "ambulatory method" and a walking-iron fitted as soon as the cast is hard (fig. 2418). Patients can walk quite satisfactorily after a little practice, even when the knee has been included in the plaster. The use of crutches should be discouraged, but one or two stout walking-sticks are necessary as a precaution against falls.

With elderly or feeble patients it is difficult or impossible to carry out ambulatory treatment, and the wiser course is to "bivalve" the cast as soon as union is firm and to treat by massage, movements, and assisted exercises.

The time necessary for complete union varies enormously. Closed fractures in healthy young adults should be firm in three to four months, but manual labourers rarely return to work under six months.

Lower Third of the Shaft of the Tibia

A common fracture, due to indirect violence, is at the junction of the middle and lower thirds of the tibia. This oblique fracture—termed *flute en bec*—is associated with a fracture of the neck of the fibula.

Displacement usually occurs and consists of angulation, rotation, and overlap with little lateral displacement.

Reduction by manipulation is not satisfactory. With skill, skeletal traction with a posterior slab may produce complete reduction in perfect position. It is often difficult to control the tendency of the lower fragment and foot to rotate.

This fracture is one in which a perfect end-result can be achieved by an open reduction, carried out preferably a few days after the injury. The approach is easy, and the bones can be replaced accurately and fixed by a six-screw Lane's plate, placed on the surface of the tibia facing the fibula. If the plate is placed on the subcutaneous surface, it will have to be removed later. The use of a plate is preferable to that of a band, more accurate and firmer than wire, and a simpler procedure than a bone graft. The limb is put into a light plaster. This is changed when the stitches are removed, in order to get a more tightly-fitting plaster over less wool. *Weight-bearing is not allowed for eight weeks.* Splinting is usually advisable for twelve weeks from the date of operation. As a rule, callus formation is neither rapid nor extensive after this operation.

In children, a partial fracture of the tibial shaft, about 2 inches above the ankle joint, is often seen, the fibula being fractured at the same level.

Deformity consists of considerable angulation in the antero-posterior plane. Manual correction under an anæsthetic is usually easy.

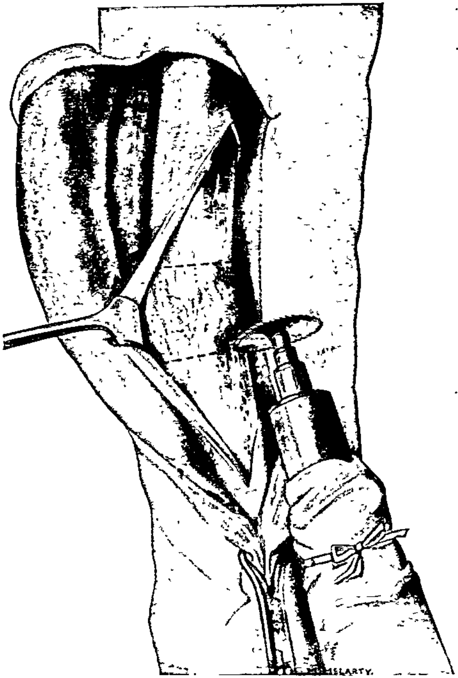

Fig. 2419.—Bone graft of the tibia for fibrous malunion. The site of fracture has been exposed, and the periosteum retracted. The dotted lines indicate the line of division of the bone with the saw.

(1) *Greenstick fracture.* If some form of fixation is not employed, a lump of callus due to the subperiosteal hæmatoma will form which is sufficient to worry the parents. A pad of felt should be placed over the site of the fracture and fixed by strapping. The arm is put in a sling and kept within the child's clothing for three weeks.

(2) *Fractures of the shaft.* The weight of the arm assisted by the pull of muscles attached to the outer fragment will cause the outer fragment to be displaced downwards, inwards and forwards. The inner fragment seldom moves.

Treatment. When displacement exists and the fracture is seen within forty-eight hours, reduction should be carried out. An anæsthetic is not required. The patient is seated in a chair and the forearm is supported by an assistant. The shoulders are grasped and drawn outwards, backwards and upwards. Pressure over the fragment is seldom helpful.

Fixation is required for a month. A pad of felt is fixed in place over the fracture with elastoplast. The method recommended is the "handkerchief method" or some modification of it. The simplest arrangement is the loose application of a triangular bandage round each shoulder. A pad of wool or felt should protect the axillæ. The ends of these bandages are tied firmly at the back between the scapulæ, so as to pull the shoulders back, and the arm is supported in a sling. A broad bandage holding the arm to the thorax should be worn at night. The objection to this method is that the bandages tend to get loose and the knots at the back are uncomfortable.

An equally efficient and comfortable modification consists in the use of two 6-inch flannel or domette bandages. A loop is made round each shoulder with the end of the bandage. The end is fixed to the length of bandage by two safety-pins over the scapula. The long end of each bandage is then grasped and pulled so that the shoulders are drawn backwards. The ends are crossed in the centre of the back and carried round the chest to be tied in front. The arm is supported in a sling.

There are ample reasons for the avoidance of Sayre's method which is commonly employed and is described in detail in most surgical text-books. The firm fixation obtained or the interest in its application may be reasons for its frequent use, although the discomfort of it is considerable. In consequence of the band round the arm, veins are obstructed and swelling and œdema occur. The extensive covering of the limb with adhesive plaster frequently causes a dermatitis and hair follicle infection. There is an unnecessary fixation of the elbow,

wrist and hand, which is painful, and massage and joint movement cannot be carried out without removing half the fixation.

Two other methods of treatment should be known, as the practitioner may have to treat either type of case. If the patient is anxious to avoid the possibility of any *visible deformity* and is prepared to remain in bed, the deformity should be reduced, even under anæsthesia if necessary. and she should lie in bed on her back. A flat sand-bag is placed vertically between the scapulæ for three weeks. The arm on the affected side is abducted to a right angle from the body and fixed by a roller towel and sand-bags. A low pillow is used and a divided mattress for use of the bed-pan.

A rather reverse line of treatment is adopted in the case of those who are anxious to continue *active use* of their arm in spite of the fractured collar-bone. It is suitable for jockeys, but those using their arms above their shoulder level should not be treated on these lines. A felt pad and strapping are applied over the site of the fracture, and a sling is worn. Radiant heat and massage are employed to cause absorption of the hæmatoma. The shoulder muscles are kept in good condition by faradism. Union will occur, but deformity is usual. A second fracture calls for greater fixation, as non-union may result.

The fixation by bandages round the shoulder, attached to wooden or metal splints applied to the back, keeps the shoulders back but is not comfortable or necessary.

Complications. Injury to the brachial plexus or to the subclavian vein is extremely rare. A case of non-union is periodically reported, and operative treatment may be required under such conditions.

Prognosis. Full functional result is obtained almost invariably. Although the outline of the bone may not be anatomically perfect and its length may be shorter than normal, the use is normal. Operative treatment is sometimes required for the complications mentioned, or for removal of a spike of bone protruding and uncomfortable owing to the braces rubbing the skin overlying it.

(3) *Interligamentous fracture* is uncommon. If displacement is present, it is reduced by placing one hand over the shoulder and inner part of the clavicle up against the neck, whilst the other hand grasps the elbow and pushes up both this and the shoulder.

When there is no displacement, the arm is placed in a sling for three weeks. At the end of that time exercises above the shoulder can be carried out.

If there has been displacement, or the shoulder is dropped and uncomfortable, a pad of sticky felt, 4×3 inches wide, is placed over the

site of the injury. A calico bandage, 4 inches wide, is passed round the padded elbow and carried vertically upwards and tied over the felt so as to force the elbow up. The free ends of the bandage are passed over the chest, one in front and one behind, so as to tie off in front of the axilla on the sound side. Adjustments may be required during the three weeks this is worn, and a sling alone will be required for a subsequent week.

SCAPULA

The types of fracture are:

(1) The *body* is broken by direct violence, such as a crush.

(2) The *acromion process* is injured by a fall on the back of the shoulder.

(3) The *neck of the scapula* and *glenoid fossa* are fractured by a heavy fall on the shoulder and arm.

(1) *Fracture of the body.* Comminution is often present, and displacement is prevented by the supporting muscles. There are signs of local injury and often dyspnœa. Other injuries frequently necessitate the patient being in bed. When this is the case, the arm should be placed in a sling, and heat and massage employed. The patient should be placed in a sitting posture, and if well enough to be up, relief will be obtained by encircling two-thirds of the chest with broad elastoplast and supporting the arm in a sling.

(2) *The acromion process* is rarely injured. The outer fragment may be tilted downwards, and the diagnosis of dislocation of the acromio-clavicular joint be made until the skiagram is seen. The treatment is similar to that of interligamentous fracture of the clavicle.

(3) The *neck of the scapula* may be fractured:

(*a*) Through the neck, including the coracoid process in the smaller fragment, or

(*b*) Into the glenoid fossa.

(*a*) This is rare. The signs are: the shoulder is flattened, there is pain on shoulder movement, the acromion and outer end of the clavicle are in normal relationship, and there is tenderness at the apex of the axilla. The X-ray film shows the body of the scapula to have been displaced towards the axilla. In a heavy woman with a large shoulder, the arm should be put in a sling, and radiant heat and massage be employed immediately. Active movements with assistance should be commenced in ten days. In a young patient with normal physique, an attempt at reduction may be employed. This consists in fixation of the axillary border of the scapula with one hand, and forcible pushing up of

the shoulder with the other hand. Fixation is on the same lines as that for *interligamentous* fracture of the clavicle.

(*b*) *Fracture of the glenoid* is usually seen as a complication of subcoracoid dislocation of the shoulder. The diagnosis in an uncomplicated case is unlikely to be made from clinical examination alone, as the signs and symptoms are those of a fracture into the joint. However, when a dislocated shoulder re-dislocates quickly after reduction, and crepitus is palpable, the glenoid is likely to have been fractured.

The arm should be placed in abduction, 90 degrees from the trunk. This can be done by plaster, which will necessitate an anæsthetic, or by a metal abduction splint. An X-ray picture should be taken to ensure that the head is not dislocated during the splinting. Movement of the fingers, wrist and elbow is encouraged. After three weeks, the arm is placed in a sling and physical treatment employed.

Prognosis after scapular injuries. After fractures of the acromion and body of the scapula, hard work should be possible with full function in eight to ten weeks. After fracture of the neck of the scapula most patients obtain full movement even when anatomical alignment is not perfect. Limitation of rotatory movement and full extension may occur, and although most occupations can be followed in three months, heavy work will not be undertaken until later.

Fracture through the glenoid is a more serious accident, and full movement, particularly above the shoulder, is unlikely to be obtained.

NECK OF THE HUMERUS

Types. (1) With no displacement.
(2) Adduction fracture.
(3) Abduction fracture.

Stereoscopic X-ray pictures are often necessary for an exact diagnosis, as a lateral view is seldom obtainable.

Type 1 (see fig. 2374—No. 1). There is a crack across the surgical neck of the humerus, and the great tuberosity is usually comminuted but not separated from the shaft. The fracture occurs only in adults, and is produced by trauma applied to the outer side of the shoulder.

The treatment consists in: (*a*) Placing in the axilla a pad of wool 6 inches square and 2 to 3 inches thick (depending on the size of the patient). The axilla is washed with spirit, dried and powdered. The wool pad is covered with gauze to prevent the wool flaking off. (*b*) Binding the arm to the side with a 6-inch bandage. (*c*) Placing the arm in a sling.

If swelling and pain are considerable, heat and massage can be

employed immediately. Bruising may extend downwards to the elbow. After three days pain is slight, and the pad and bandage can be left off and the arm kept in a sling. Active exercises, especially abduction and external rotation, should be commenced and practised

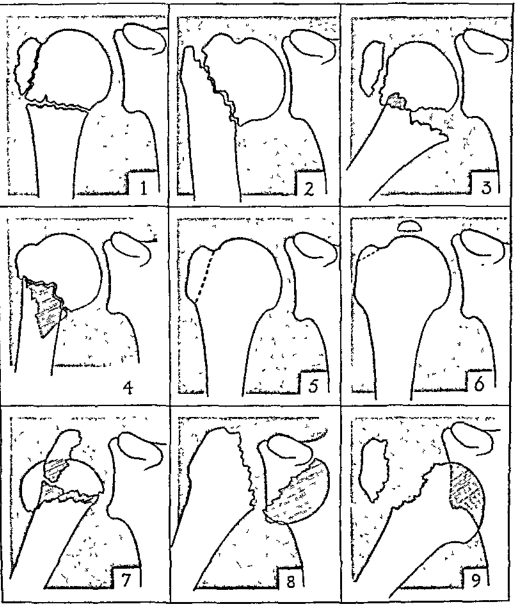

Fig. 2374.—Diagram of fractures and fracture-dislocations of the neck of the humerus.

1. Humeral neck crack and fracture of great tuberosity.
2. Oblique fracture of neck.
3. Fracture of neck and tuberosity with displacement.
4. Fracture of the neck in childhood (separated epiphysis).
5. Fracture of tuberosity.
6. Avulsion fracture, showing displacement of that portion of tuberosity to which supraspinatus muscle is attached.
7. Fracture dislocation. Impaction with lateral displacement of the head.
8. Fracture-dislocation. The head is in the position of a subcoracoid dislocation.
9. Fracture dislocation. The great tuberosity is fractured. The head, not broken from the shaft, is in the position of a subcoracoid dislocation.

frequently for ten minutes at a time. The forearm, hand and fingers should be used as much as possible.

A full range of movement should be obtained in two to four months. Difficulties only arise owing to prolonged immobilisation. If the arm is immobilised for a number of weeks, adhesions occur in the capsule between the humerus and lower part of the glenoid so that abduction and external rotation are limited and painful. Pain usually persists over the front of the joint. Such a condition is seldom relieved by physio-therapeutic measures alone, and manipulation under an anæsthetic is required to regain movement.

Type 2 (see fig. 2374—No. 2). There is an oblique fracture extending through the lower part of the great tuberosity downwards and inwards. The tuberosity is not separated, and there is often impaction of the inner part of the fracture. The injury is caused by a fall on the outstretched hand, the limb being carried inwards (adducted) at the moment of the impact. The fracture is most common in elderly patients and often in heavy women. If the fracture is impacted, the treatment is identical with that of Type 1. If it is not impacted, pain is usually greater, and the movement between the fragments can be felt by the patient and examiner whenever the elbow is moved. The fragments will soon adhere together, and release from the chest bandage and commencement of active exercises should not be delayed longer than one week. The sling should be left off as soon as possible and certainly not be used all day after a month. Some limitation of abduction and external rotation is frequent in elderly patients but is not considered a severe disability by them. An anæsthetic, manipulation, or prolonged fixation is undesirable.

Type 3 (see fig. 2374—No. 3). There is a transverse or slightly oblique fracture (upwards and inwards) through the top of the humeral shaft, and the great tuberosity is separated from the head. There may be a slight displacement of the shaft inwards, with outward and backward rotation of the head, with or without impaction; or, the upper end of the shaft may lie in front and to the inner side of the head.

The fracture results from a fall on the outstretched hand when the arm is straight and away from the body. The treatment and prognosis cause greater anxiety than in the case of Types 1 or 2. When the fracture is across the shaft, the treatment is easier than when there is a spike on the inner part of the shaft.

If there is little displacement and impaction, no manipulation is advised. Otherwise, an anæsthetic is given and the displacement corrected. Traction is applied to the arm in an adducted position (i.e.

arm across the chest) and pressure is applied to the top of the shaft by a hand in the axilla. This is directed to replace the fragment or impact it into the head. A pad is placed in the axilla, and the limb is fixed to the side for three weeks. Radiant heat and massage can be employed to relieve pain, without removing the bandage. After three weeks a sling is used and active movements are encouraged. Faradism to the muscles round the shoulder may be helpful.

When there is little displacement of the fracture, good function is obtained after the manipulation. If no reduction is attempted, or failure to correct the deformity results from the manipulation, there is invariably limitation of abduction, external rotation, and extension. An elderly patient is more likely to complain of pain in the shoulder than of permanent limitation of movement. Therefore, the question may arise as to whether further attempts at reduction and fixation should be employed. In the middle-aged patient this is advised. An abduction splint—such as holds the elbow away from the side—should be avoided, as further abduction of the shaft on the head of the humerus may occur and the end-result be one of considerable limitation of abduction.

Improvement in alignment is sometimes obtained by putting the patient to bed, with an extension on the arm. A splint similar to a Thomas thigh splint is employed. This should not be kept on for more than three weeks. The elbow should be moved daily after ten days, the extension being released for this purpose, unless a double fitting is added to the splint. I have not seen difficulty in the arm coming to the side after this method of treatment, but a stiffness of the elbow is inevitable in an adult if it is fixed for a number of weeks. Operative treatment is not required; removal of the head of the humerus is followed by great weakness of all movements at and above the level of the shoulder, so that a patient cannot take a book from a shelf above the level of the head. Jones' arm splint with extension bands over the metal bars beyond the elbow is not comfortable when used for the treatment of this fracture.

After union or malunion, the X-ray appearance is no criterion of the function of the shoulder.

Fracture of the neck of the humerus in children (see fig. 2374—No. 4). This is caused by a fall on the outstretched hand when the arm is in front of the body, or rarely by a fall on to the shoulder.

It is almost invariably of the adduction type. The fracture line is extraordinarily constant; the head of the humerus, the cartilaginous plate, and a wedge-shaped piece of the outer part of the metaphysis form the upper fragment. If there is displacement there may be (*a*)

impaction on the inner side with crushing, or (*b*) displacement of the shaft forwards in an adducted position.

When there is no displacement, the treatment is straightforward —a pad in the axilla, and fixation of the arm to the side for three weeks, and then in a sling for three weeks. Early movement may cause displacement and is of no advantage as a child or adolescent will readily regain movement.

When there is displacement, an anæsthetic should be given and the deformity corrected by traction on the arm, which should be held at an angle of 45 degrees from the side of the body. Pressure on the outer side of the head of the humerus will help in the correction. Sometimes reduction can be accomplished by traction with the arm across the chest. A pad is then placed in the axilla and the case treated as if there were no displacement. A skiagram of the shoulder should be taken to ascertain whether the position is satisfactory. If this method of correction fails, a decision must be made whether to leave the deformity or to correct it by open operation. The latter consists in exposing the fracture on the outer side, placing the fragments in position, and fixing the arm to the side. Internal fixation by a plate, screw, etc., is seldom required, as it is usually possible to produce and maintain a perfect or nearly perfect position without its help. However, if the shaft is left in front and to the inner side of the epiphysis, it will unite, but the humerus will be short in adult life owing to the union with overlap and premature disappearance of the epiphysial plate. There is likely to be a shelf at the top of the shaft for two years or more, with slight alteration in the appearance of the shoulder, but full function. I have seen a subluxation of the sterno-clavicular joint follow a malunion of the upper end of the humerus in a girl of thirteen, possibly owing to her zeal to regain full movement quickly.

This fracture with displacement should not be treated in abduction on an abduction splint. In a few cases the shaft, before it is "gummed" on to the epiphysis, will sink downwards so that the fracture becomes an abduction fracture, and the elbow is held away from the side when the arm is removed from the apparatus.

Fracture of the Great Tuberosity (*uncomplicated*).

This may consist: (1) of a comminution of the whole tuberosity with little or no displacement, or of a separation of the whole tuberosity (see fig. 2374—No. 5), either of which is caused by a direct blow or fall; or (2) of a slight or complete avulsion of the portion of the tuberosity, into which the supraspinatus muscle is inserted (see fig. 2374—No. 6). This is due to traction injury.

In either type, when there is *no displacement*, the arm is placed in a sling, which is worn continually for two weeks. After that time, the patient is encouraged to do without it as much as possible. Heat and massage are employed from the date of injury, the elbow and wrist being used throughout. Active exercises can be commenced in three days, when the immediate pain has disappeared. Adhesions are particularly liable to form if the shoulder is immobilised, and active movements will be painful and restricted if the shoulder is moved by a masseuse.

Although this appears to be a trivial fracture, pain and stiffness often last for some weeks, and full movement with freedom from discomfort may not occur for two and a half to four months.

When there is *displacement*, it is necessary to bring the bony fragment in contact with the humerus, for the deltoid cannot abduct the arm more than 45 degrees from the body, unless the supraspinatus is active as a fixation muscle for the head of the humerus.

Treatment therefore consists in placing the arm in an abduction frame, in a position of 90 degrees abduction and external rotation, so that the hand is above the head. This position must be maintained for eight weeks, during which time the fingers, wrist and elbow must be exercised. At the end of that time, the arm is gradually brought to the side and is kept in a sling for two weeks. If the apparatus permits, faradic stimulation of the deltoid can be employed during the weeks of immobilisation in the splint.

This small fracture leads to disability—viz. weakness of abduction and all overhead movements, unless the fragments are approximated. In view of the discomfort of the apparatus it is reasonable to advise the patient that by operative means the length of time the arm is out of action can be shortened. Such a procedure is definitely advisable if the fragment has been allowed to remain displaced for ten days. The operation consists in exposure of the fragment and its fixation in the normal position by means of a small bone peg or screw driven through it into the head of the humerus. Firm fixation is thus possible and, after ten days, treatment will be carried out as if there was a fracture with no displacement.

FRACTURE-DISLOCATION OF THE SHOULDER

Type 1. There is a fracture, usually oblique, at the upper end of the humerus with dislocation of the head of the humerus out of the glenoid fossa. When the fracture is impacted, the great tuberosity is usually broken off, and the head displaced laterally into the top of the broken shaft. (See fig. 2374—No. 7.) In the unimpacted type, the head tears

the capsule and comes to lie in the subcoracoid area. This serious injury results from a fall on the outstretched hand when the arm is abducted. The treatment is difficult.

The impacted fracture. Manipulative reduction is usually possible, owing to the firm fixation of the bones. If it is successful, the head remains on the outer side of the top of the shaft. Disimpaction of the shaft from the head generally results in aseptic necrosis of the head, and is not advisable. In elderly patients, in those whose general health contra-indicates operation, and in left arms, the patient is prepared to accept disability; in such cases it is advisable to put the arm in a sling and employ physio-therapeutic methods without delay. The end-result will provide the patient with not more than 50 per cent of normal movements. Movements below the shoulder level are not likely to be painful. Complete ankylosis of the joint does not occur if early movement is employed. In younger and fitter patients, open operation is advisable. The joint is exposed by means of an anterior incision through the deltoid muscle. The head is disimpacted and the parts inspected with a view to fitting them together. There is comminution of the cortex of the upper end of the shaft, so that exact reposition is difficult. The choice rests between impacting the head on to the shaft in correct alignment and fixing the great tuberosity lower down than its normal situation, or fixing the head into the shaft by an intramedullary peg or graft. Satisfactory results may follow either of these procedures if carried out soon after the injury, but a successful end-result is sometimes marred by aseptic necrosis of the head, due to gross injury to the blood supply to the head. Such a complication usually leads to complete, or nearly complete, ankylosis, or painful arthritis may follow.

The unimpacted fracture (see fig. 2374—No. 8). Manipulation under anæsthesia is indicated. The head of the bone is located and one hand placed on it. With the other hand, traction is applied to the arm drawn across the chest. It is gradually carried outwards whilst firm pressure is made on the head. If that fails, the arm is carried further outwards and upwards so that traction is applied with the arm above the level of the shoulder. Successful reduction is more likely to follow if it is carried out soon after the injury. The arm is fixed to the chest for three days and is then placed in a sling; exercises, heat and massage are employed.

Failure of reduction necessitates open reposition of the head by an operation on the lines already indicated.

Type 2. The great tuberosity may be fractured, or the supraspinatus avulsed as a complication of subcoracoid dislocation of the

humerus. (See fig. 2374—No. 9.) Such a complication occurs in one-third of all shoulder dislocations. When the tuberosity is fractured from the shaft, it is usually found that after reduction of the dislocation there is little displacement. A large pad is placed in the axilla, and the arm is fixed to the side for ten days. Radiant heat and massage are employed on the shoulder, active exercises are encouraged, and the arm is placed in a sling. Full movement is seldom obtained in elderly patients and the period of disability is often as long as six months.

Complications of Shoulder Injuries.

Stiffness and *ankylosis* of the joint occur in consequence of some of the injuries described even after the most efficient treatment. They are more likely to form in elderly patients and when there has been an effusion of blood in the joint for some period. The means of prevention are early treatment of dislocation and fracture, accurate replacement of bone, early active movements and the avoidance of passive movements.

Nerve injury complicates dislocation frequently but fracture seldom. Fracture-dislocation causes a somewhat greater number than either lesion. The circumflex nerve paralysis or paresis is as frequent as all the other nerve injuries combined. Posterior cord lesions affecting the triceps and wrist and finger extensors, as well as the deltoid, are next in frequency. The diagnosis is usually made two to three weeks after the initial injury, probably because the muscle weakness is considered to be the result of bruising only. Permanent paralysis is very rare.

Circumflex paralysis (affecting the deltoid muscle) usually recovers in three to four months. Treatment consists in relaxation of the affected muscle by splinting, and in electrical stimulation. In deltoid paralysis, an abduction splint should be employed. If this is contra-indicated by the bone or joint injury, the latter must receive the primary consideration for two weeks.

SHAFT OF THE HUMERUS

Fracture of the shaft usually results from direct violence. It is not common in children, except through a cyst in the upper third of the shaft. In adults it is seen in the upper third and across the middle of the shaft. In the latter situation, it is usually a transverse fracture with a notch in one fragment and a spike on the other. In the upper and lower thirds a long oblique fracture generally occurs, and quite frequently there is one fragment broken off, which is often 3 inches in length. Doubt about diagnosis does not occur and the exact injury is seen in the skiagram. The muscles of the forearm and hand should be tested in order to appreciate at the outset if there is any nerve

involvement, such as musculo-spiral paralysis. The general principles of treatment are those applicable to a fracture of the shaft of any long bone, viz.:

(1) Early and accurate setting under an anæsthetic.

(2) Firm fixation.

(3) Early movement of those parts not fixed in the splinting—in this case, of the wrist and fingers.

Three facts are outstanding: first, the request that the fracture may be treated without confinement to bed; secondly, the difficulty of employing a comfortable method of fixation; and, thirdly, the periodic occurrence of non-union of transverse fractures of the middle of the shaft of the humerus, with formation of a pseudarthrosis.

There is seldom any reason for treating a fractured humeral shaft in bed, provided the general condition is good, but elderly patients are often better in bed for a few days. The other points are considered appropriately below.

The routine treatment consists in an anæsthetic for the setting. A Jones splint is employed, elastoband or strapping extension is placed on the inner and outer surfaces of the arm, and oblique narrow strapping fixed over this (fig. 2375). The axilla is powdered and the splint applied. The ends of the extension bands are tied round the notches, a strip of metal is placed to keep the vertical bars equidistant, and the forearm is rested in a trough of flannel bandage. The arm is adjusted until it is thought to be straight. One or two short wood, metal or plaster splints are placed round the arm and a flannel band is passed round the inner vertical bar and pinned to the outer bar.

A skiagram is then taken to check the position, and readjustment made if necessary, care being taken that the fragments are not separated. This apparatus is not very comfortable, particularly in bed. The greatest comfort is obtainable by the patient sleeping with a back-rest, the splint being placed outside the pillow and back-rest. The forearm should not be drawn across the chest or abdomen; this is not only uncomfortable, but rotates the lower fragment. Swelling of the elbow usually occurs. The axilla must be cleansed with spirit and powdered. Adjustment of the extensions is not often required. In the case of a transverse fracture, this splint should be worn until there is radiological evidence of good callus formation. In oblique fractures the fragments adhere together quickly, and non-union never occurs. It is usually safe after three weeks to remove the splint, and to make a posterior plaster trough for the forearm and arm and a short anterior

splint. These can be fixed round the arm with webbing and buckles and removed for physical treatment. Short splints round the arm itself are required during the last few weeks of fixation, which is often necessary for as long as eight weeks in transverse fractures.

Complications. A fracture through a cyst of the upper third of the humerus is seen in children. As a rule, the fracture is the first evidence of the cyst. Although such a cyst diminishes in size after the hæmorrhage into it from the fracture, it seldom disappears altogether, so

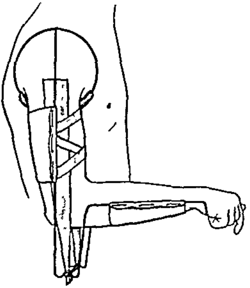

Fig 2375.—Jones' arm splint. Extension is applied to the arm. The forearm is shown pronated, which is more comfortable than supinated, but supination movements should be employed.

Fig 2376.—Skiagram showing fracture of the humerus with one loose fragment. Typical fracture complicated by musculo-spiral paralysis.

that it is advisable to expose the cyst, remove the contents, and splint the arm to ensure a cure.

Fracture of the lower third of the humerus is complicated by injury to the *musculo-spiral nerve* in a number of cases. Usually the fracture is oblique and there is a spike on the top of the lower fragment (fig. 2376). When the paralysis is incomplete, it is reasonable to splint the arm and to employ electrical treatment for the muscles. If the injury has been a bruising of the nerve, quick recovery may ensue. If there is no recovery or increased paralysis in three weeks, the case should be treated on the same lines as a complete paralysis recognised at the time, namely, by operative treatment.

The incision should be sufficient to expose the nerve above and below the site of the supposed lesion, together with the whole length of the fracture. It is usually convenient to make the incision along the anterior border of the brachio-radialis, and to extend it upwards and curving slightly round the back of the arm at the level of the musculo-spiral groove. The nerve should be exposed above and below the supposed lesion and traced up and down gradually until the lesion is found. The nerve is protected whilst attention is being paid to the bone. This should be accurately aligned and the fragments fixed together by the method to which the surgeon is most accustomed—plating, pegging, or such-like. A piece of triceps is then sutured over the fracture. The nerve is sutured or treated as appears necessary (see Vol. II, page 3471) and placed in the new bed protecting it from the bone. Flexion of the elbow is advisable to prevent tension of the nerve. A light plaster trough is applied. After-treatment for the fracture and nerve is on the lines indicated in Vol. II, page 3480. Injury to the brachial vessels or to the median or ulnar nerve is rare in association with simple fractures of the shaft of the humerus.

LOWER END OF THE HUMERUS

Injuries of this region are common and, although a great variety exists, a definite grouping of types is possible:

(1) Supracondylar fracture.
(2) Fractures of the internal epicondyle.
(3) Fractures of the external condyle.
(4) Complicated fractures.

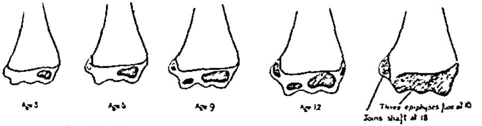

Fig. 2377.—Mode of ossification of epiphyses of lower end of humerus.

The first three groups occur almost entirely in children, usually under the age of twelve. Falls on the elbow or on the hand which cause these injuries in children frequently result in fractures of the head or neck of the radius in adults. Examination of an elbow before swelling has occurred shows the position of the bony points—olecranon and epicondyles—which is information of clinical importance, but they are quickly concealed by swelling. Radiography provides exact information,

as lateral and antero-posterior views are easy to take and to interpret if one has an accurate knowledge of the normal shape and ossification of the lower end of the humerus (fig. 2377). Such information is obtained, not only from a knowledge of anatomy but from studying skiagrams of the part at different ages. The average ages of ossification of the epiphyses are indicated in the diagram. The dates are liable to variation and those quoted are rather later than is common in this country.

(1) *Supracondylar Fracture* (fig. 2378, A and B)

The *line of fracture* is obliquely upwards and backwards from the epiphysial line, so that a portion of the shaft is on the distal fragment.

A B

Fig 2378.—SKIAGRAMS OF SUPRACONDYLAR FRACTURE OF HUMERUS WITH BACKWARD DISPLACEMENT AND TILT. A. BEFORE REDUCTION. B AFTER REDUCTION

If there is *displacement*, it is upward and backward, often with lateral or medial displacement. Anterior displacement is rare, and rotation may occur in any case.

Treatment. (*a*) When there is no displacement, the arm is fixed in as full flexion as is compatible with safety to the vessels, by one of the methods described later.

(*b*) When there is displacement, an anæsthetic is given. The elbow is extended and the forearm supinated; if the fracture does not feel loose, the deformity is increased, and firm traction is applied to the forearm, *whilst the elbow is gradually flexed. During this procedure the other* hand makes pressure on the *front* of the lower end of the humeral shaft. The extent of flexion should be such that there is no interference with

the flow of blood through the brachial artery, which can be detected by feeling the radial pulse, or with the venous return through the veins in front of the elbow.

Fixation is made by elastoplast round the wrist and the upper end of the forearm and by placing the arm in a sling which prevents the angle between forearm and arm being altered.

The radial pulse is again felt, in order to make sure that the circulation is satisfactory.

The elbow is inspected next day and, all being satisfactory, the method of fixation is not changed for three to four weeks (the longer period for the older child). The elbow is then placed in a sling for a week and the child is told to touch the shoulder frequently so as to keep up the flexion. Extension will come back by usage. Exercises are not necessary, and the carrying of weights may be harmful. Massage and passive movements must not be employed.

Alternative methods of fixation are numerous. The "collar and cuff" fixation of the wrist to the neck is popular, but has the disadvantage that the child's forearm usually becomes pronated immediately after the setting and varus deformity may result.

By perfect setting and fixation and rest, a perfect result is anticipated.

Forward displacement is reduced by traction and pressure on the fragment in the antecubital fossa. Methods of fixation and after-treatment are similar to those employed for the common fracture.

Difficulties and Complications.

(*a*) *Excessive swelling of the elbow* and blistering of the skin of the antecubital fossa occur in a proportion of cases. They are most frequent when the arm is left untreated for a few days, when unnecessary force has been employed in setting the fracture, and when several attempts have been made at reduction. This complication is particularly common when the setting is faulty. The treatment is by avoidance of the causes. When swelling has formed, care must be taken that the flexion is not so acute as to interfere with the circulation. The blisters should be treated by sterile puncture, and by the application of powder and a strip of boracic lint which should be left in the fold of the elbow until the part is dry and the swelling subsiding.

(*b*) *Imperfect reduction* may be: (i) persistence of some backward displacement, or (ii) lateral displacement.

(i) When the fragments are hitched and there is no backward tilting, it is often advisable to leave the fracture in this position, although there is not a perfect anatomical position. When the fragments have joined, there is somewhat of a beak at the lower end of the

shaft at the site of the fracture. This will absorb after a number of years.

(ii) If lateral or mesial displacement is not corrected, alteration in the carrying angle will occur. Failure to correct mesial displacement will produce cubitus varus—gunstock deformity—whereas persistence of lateral displacement causes an increase in the carrying angle. Persistence of these deformities may necessitate osteotomy of the lower end of the humerus a few years later.

(c) *Nerve injuries.* The median nerve is sometimes injured by pressure of the lower end of the shaft upon the posterior aspect of the nerve. This may occur when the backward displacement is great, or when too forcible hyperextension is employed in reduction. The sensory loss usually affects the distal two-thirds of the first and second fingers, while the motor paralysis involves the thenar eminence and the median lumbrical muscles. Recovery occurs, as a rule, in three months, but may be delayed for a year. Very rarely are the musculo-spiral and ulnar nerves affected in supracondylar fracture.

(d) *Volkmann's ischæmic contracture.* This rare complication is not likely to occur if early and accurate reduction is carried out. The early symptoms may commence a few hours after interference with the circulation, and consist of pain and numbness of the fingers and hand. The fingers are discoloured early and lose voluntary movement. The treatment is considered on page 4384.

(e) *Myositis ossificans* is discussed on page 4381. Although it may commence soon after forcible manipulation or massage, symptoms do not arise for three weeks. The essential treatment is rest by placing the arm in plaster-of-Paris. Early operation should not be performed. Small areas of bone will absorb, but weeks or months of rest may be necessary. If bone absorption is incomplete and a series of skiagrams taken at monthly intervals shows that the new bone is remaining unchanged, it is advisable to remove the plaque of bone causing obstruction.

(2) *Fractures of the Internal Epicondyle*

These are essentially fractures of childhood, occurring about the age of twelve. The epiphysis alone is usually separated, but a small flake of diaphysis may be adherent. The fracture results from a forcible abduction of the forearm on the arm, and it may complicate a dislocation of the elbow joint.

Type 1. A small chip may be torn off, or the epicondyle may be fragmented, without displacement. The treatment consists in flexion of the elbow for three weeks, followed by active exercises.

the flow of blood through the brachial artery, which can be detected by feeling the radial pulse, or with the venous return through the veins in front of the elbow.

Fixation is made by elastoplast round the wrist and the upper end of the forearm and by placing the arm in a sling which prevents the angle between forearm and arm being altered.

The radial pulse is again felt, in order to make sure that the circulation is satisfactory.

The elbow is inspected next day and, all being satisfactory, the method of fixation is not changed for three to four weeks (the longer period for the older child). The elbow is then placed in a sling for a week and the child is told to touch the shoulder frequently so as to keep up the flexion. Extension will come back by usage. Exercises are not necessary, and the carrying of weights may be harmful. Massage and passive movements must not be employed.

Alternative methods of fixation are numerous. The "collar and cuff" fixation of the wrist to the neck is popular, but has the disadvantage that the child's forearm usually becomes pronated immediately after the setting and varus deformity may result.

By perfect setting and fixation and rest, a perfect result is anticipated.

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(3) *Fractures of the External Condyle*

These fractures are uncommon, representing less than 1 per cent of all fractures. They are more common in children than in adults, and result from indirect trauma. In children, the mechanism of fracture is adduction of the forearm with the elbow incompletely extended, the strain producing an avulsion of the fragment from the humerus.

Type 1. In *adults*, the piece of bone broken off consists of the capitellum, part of the trochlea, and a piece of non-articular bone above and behind the articular area. There may be no displacement or forward displacement with rotation of the fragment. The exact diagnosis is of importance, as the fracture extends into the joint and a small displacement disturbs the normal joint mechanism. If there is no displacement, the elbow is put at rest at a right angle in a posterior plaster trough. Displacement is an indication for open operation. The joint is opened on the outer side so as to expose the lower end of the supracondylar ridge, the fractured piece of bone and the head of the radius. Blood clot is cleared away and the fragment rotated into place. In most cases fixation is not required, but if the fragment does not remain in place, it must be fixed by catgut passed through a drill hole made in the diaphysis, or a bone peg (one-eighth of an inch in diameter) may be driven transversely through the fragment to fix it to the trochlea. The elbow is put at rest for three weeks, after which active exercises are commenced.

Type 2. In *children*, the fractured piece consists of the capitellar epiphysis (the capitellum and half the trochlea) and a thin flake of diaphysis, off the back of the lower end of the humerus (see fig. 2380). When there is no displacement, the elbow is flexed and the case treated like *a supracondylar fracture with no displacement*. When there is displacement, manipulative reduction is seldom successful and open operation is necessary or else non-union of the fragment and cubitus valgus will result. The extent of exposure has been indicated. The fragment will be found to be rotated and lying often in the soft parts, owing to a tear of the muscular aponeurosis overlying the condyle. The lateral ligament is not torn and acts as a hinge on which the fragment rotates. The fragment is rotated into position and some form of fixation is necessary to prevent its lateral displacement; a catgut stitch usually suffices and a peg or nail should be avoided, as such a foreign body is likely to interfere with epiphysial development. Active movements are commenced after three weeks' fixation. Normal elbows are obtained after efficient reposition.

Complications. If the fragment is not rotated and fixed into its normal position, the lower end of the humerus will develop into an abnormal shape. The inner side will grow and the outer side be stunted, while the capitellar epiphysis will grow into a somewhat mushroom-shaped mass separated from the humerus. Cubitus valgus will be present and the arm will be weak. Later in life, ulnar neuritis or paralysis will develop owing to the tension of the nerve as it passes round the internal epicondyle of an arm with cubitus valgus.

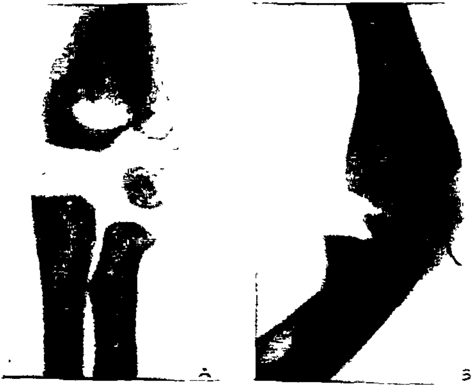

Fig. [illegible].—Radiograms showing fracture of the capitellar epiphysis with a flake of diaphysis. The fragment is displaced and rotated.

Type 3. External epicondylar fractures are isolated and uncommon. There is pain and tenderness. Union will occur if the muscles are relaxed.

(4) *Complicated Fractures of the Lower End of the Humerus*

This group includes T and Y fractures, which may occur with or without dislocation. Comminution o [illegible] , of the elbow joint occurs sometimes, commonly with fr [illegible] . Usually there is gross deformity and it is imp [illegible] fragments by manipulation. Recently attem [illegible] obtain alignment by skeletal traction applic [illegible]

At the onset it must be realised that full elbow movement is seldom obtained, but 90 degrees of movement is usually possible if early operative treatment is undertaken. Osteo-arthritis does not occur to such an extent as after a comparable fracture into the knee joint. The operative procedure should aim at:

(*a*) Reposition of all large fragments.
(*b*) Fixation by extra-articular means, whenever possible.
(*c*) Removal of small fragments.
(*d*) Enlargement rather than diminution of the joint space by the operative procedure.

The best incisions are placed laterally, and the surgeon should have the care of nerves and vessels in mind.

These principles are carried out in T and Y fractures by seeing that no small fragment is impeding an accurate placing together of the articular cartilage at the lower end of the humerus. The fixation is carried out by screws, wires or a plate, placed extra-articularly. The mechanical method employed must depend on the surgeon's experience with such means of fixation.

A comminuted fracture of the capitellum, the head of the radius, and the olecranon with posterior dislocation may be seen after heavy falls. This is best treated by open reduction of the dislocation, fixation of the olecranon, and removal of the fragments of bone from the outer side of the joint. A large and clean gap should be made between the top of the radius and the lower end of the humerus. Such a procedure may leave an arm with over 100 degrees of painless movement. After operation of this type, the arm should be placed in a plaster trough for a month, shoulder and finger movements being encouraged from the outset. Then heat and active exercises can be started, the patient wearing a more tightly-fitting trough which can be removed daily for treatment. After six to eight weeks, a sling is substituted. Passive movements and massage are prone to produce ossification in ligaments and muscles round the joint and should be avoided.

FRACTURES OF THE RADIUS AND ULNA WITHIN THE ELBOW JOINT

Such injuries are usually caused by falls on to the elbow, but a fall on to the outstretched hand may produce an injury to the head or neck of the radius.

These fractures are classified together to remind the practitioner that the fracture is within the confines of the joint and that therefore the prognosis is liable to be more serious than after fractures of the shaft. From the point of view of diagnosis the common features are pain,

Complications. If the fragment is not rotated and fixed into its normal position, the lower end of the humerus will develop into an abnormal shape. The inner side will grow and the outer side be stunted, whilst the capitellar epiphysis will grow into a somewhat cubical-shaped mass separated from the humerus. Cubitus valgus will be present, and the arm will be weak. Later in life, ulnar neuritis or paralysis will develop owing to the tension of the nerve as it passes round the internal epicondyle of an arm with cubitus valgus.

Fig. 2380.—Skiagrams showing fracture of the capitellar epiphysis with a flake of diaphysis. The fragment is displaced and rotated.

Type 3. *External epicondylar* fractures are isolated and uncommon. There is pain and tenderness. Union will occur if the muscles are relaxed.

(4) *Complicated Fractures of the Lower End of the Humerus*

This group includes T and Y fractures, which may occur with or without dislocation. Comminution of the bones of the elbow joint occurs sometimes, commonly with fracture of the olecranon. Usually there is gross deformity and it is impossible to assemble the fragments by manipulation. Recently attempts have been made to obtain alignment by skeletal traction applied through a wire in the olecranon.

At the onset it must be realised that full elbow movement is seldom obtained, but 90 degrees of movement is usually possible if early operative treatment is undertaken. Osteo-arthritis does not occur to such an extent as after a comparable fracture into the knee joint. The operative procedure should aim at:

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(c) Removal of small fragments.
(d) Enlargement rather than diminution of the joint space by the operative procedure.

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These fractures are classified together to remind the practitioner that the fracture is within the confines of the joint and that therefore the prognosis is liable to be more serious than after fractures of the shaft. From the point of view of diagnosis the common features are pain,

swelling of the joint, and limitation of movement with local tenderness; whereas extravasation of blood is usually extensive after a fractured olecranon. it may be absent after a fractured head of the radius. Bleeding into the joint is common to all these injuries.

The group consists of:

(1) Fractures of the radius—(*a*) head: (*b*) neck.

(2) Fractures of the ulna—(*a*) olecranon; (*b*) coronoid process.

(1) *Fractures of the Radius.* These occur nearly four times as frequently as injuries to the outer side of the lower end of the humerus. Of 3000 consecutive ambulatory fractures, the head of the radius was

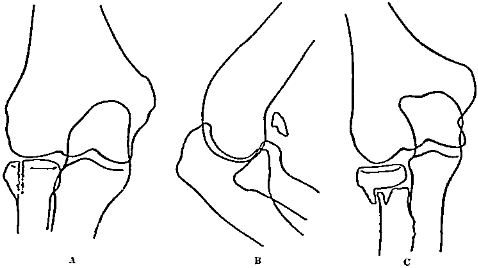

Fig. 2381.—A. Vertical fissure fracture of head of radius. B. Fracture of head with displaced fragment. C. Fracture of neck with rotatory displacement.

fractured in 124, and the neck in 37. whereas the capitellum and external epicondyle were fractured in 45. The average age of the "head" injury was 22 and that of the neck 14.

(*a*) Fractures of the *Head of the Radius* are of three types:

(i) A vertical fissure, descriptively termed a "chisel fracture" (fig. 2381A).

(ii) A fracture with one loose fragment (fig. 2381B).

(iii) Comminution of the head, including the mushroom fracture.

(i) and (ii). The diagnosis of either of these injuries will remain in doubt until a skiagram is taken. When little or no displacement occurs. treatment consists in full supination and flexion. This is possible if the patient is seen shortly after the injury, but if the joint is allowed to swell before treatment is commenced, it will only be possible to flex the elbow to a right angle or so. By use of a collar and cuff or special

sling, the extent of flexion will be increased by daily adjustment. This position is retained for four weeks, and then for one week the elbow is in a sling at a right angle. After that, flexion and extension exercises are commenced. Good function is present in eight weeks, but full function is often not obtained for four months.

(ii) When one loose fragment is displaced, this should be removed by open operation. The ideal time for this is within one week of the injury. It is carried out through an incision on the outer side of the joint. At operation, further fissuring of the head is sometimes seen. This may involve articular cartilage only, and when no displacement is present other than of one fragment the operation should be limited to removal of the fragment.

(iii) The comminuted fracture is a more serious injury than the two already described. The several fragments are separated so that the total circumference of the head is increased and rotary movement greatly limited. The treatment consists in removal of the head and part of the neck of the radius. The best results are obtained by primarily putting the arm at rest at a right angle in a sling for six weeks. Then operation is carried out. This has two advantages: that ossification of the capsule will occur neither before the operation nor following it. Formation of small spicules of bone and thickening of ligaments are the usual causes of limited movement after early removal of the radial head. The disadvantage is that there is a six-weeks' delay for the patient, but the end-result is worth the delay. After the delayed operation, a full range of movement is sometimes obtained, but the usual end-result is permanent limitation of 20 degrees of extension with a full range of other movements.

The operation of removal of the head of the radius is carried out through an incision in the line of the forearm from the external epicondyle downwards. As the lower end of the incision should not be as distal as the point where the posterior interosseous nerve winds round the radius, it is often advisable to extend the incision upwards.

The aponeurosis of the extensor muscles is split in the line of its fibres and retracted. The capsule is picked up at the level of the capitellum and incised in the line of the incision down to the neck of the radius. The head of the radius is now exposed. Blood clot is removed if present. If the head is loose, this is removed and the upper end of the shaft trimmed. If the head is joined to the shaft, a half-inch chisel is used to cut through the neck about a quarter of an inch distal to the head. The stump is trimmed with bone forceps. The synovial membrane and aponeurosis are closed in separate layers. After closure

of the skin, the arm is placed for three weeks in a light plaster trough extending from the axilla to the wrist. After that interval active movements are instituted.

(*b*) *Fractures of the Neck* are usually transverse and just below the head, but a wedge-shaped piece of bone is frequently detached from the shaft with the " head fragment."

In the case of children (for this injury occurs between the ages of six to twelve) the line of fracture is distal to the cartilaginous plate through the top of the shaft. In one-third of these cases there is displacement.

Treatment. With little or no displacement, the condition is treated as if there were a fissured fracture of the head of the radius.

Displacement may consist of: (i) a tilt; (ii) rotation of the head and neck on the shaft (see fig. 2381c); (iii) the head being alongside the shaft, or removed away from it, even to the inner side of the forearm; or (iv) comminution and displacement.

Operative treatment is indicated in:

(i) and (ii). In these cases, it is necessary to make the decision as to whether a better elbow will be obtained by leaving the bone to join with the deformity or by operation. This is a difficult decision to make. At the time of the examination soon after the injury, the range of movement is limited not only by the mechanical obstruction due to the displacement, but also by spasm of muscle and effusion into the joint. Hence the X-ray appearance is the principal help in the decision. In patients over fifty years of age, the case will be treated by immobilisation in as full flexion as possible for three weeks. In younger patients, a small degree of tilt or rotation will be treated similarly, but a tilt to the ulna, a 30 degree tilt in any direction, or a rotation through more than 45 degrees (often shown by the wedge-shaped piece of bone on the neck) are indications for operative treatment, as a manipulation will not correct these deformities. The operation will consist of an exposure of the head of the radius and of the line of fracture. The displacement is corrected, and frequently a slight impaction will hold the fragment firm. Complete rest for three weeks is advisable before active movements are commenced.

(iii). Manipulative reduction of a displaced head is seldom successful. It is more likely to be possible a few hours after the injury than later. I have seen two repositions in children but none in an adult. Hence it can be given a trial, with the realisation that it may fail. If there is failure, operation should be carried out within one week of the injury. The outer side of the joint is exposed, as has been described for removal

of the head of the radius. It is essential to use a tourniquet, and a pneumatic one is the safest.

The head is located, and care taken not to tear any periosteum or capsule which may be adherent to the neck or fragment. The upper end of the shaft is cleared of clot, but not trimmed. The head is replaced. It is usually possible to tell by spicules of bone around the edge of the head and neck how the head should fit on. If the head can be slightly impacted into the neck, this is carried out. Additional help in fixation may be possible by passing catgut through any soft tissue adherent, or by two drill holes distal to the articular cartilage through which a stitch can be passed. The forearm should be pronated and supinated to ensure that the head is not displaced by these movements.

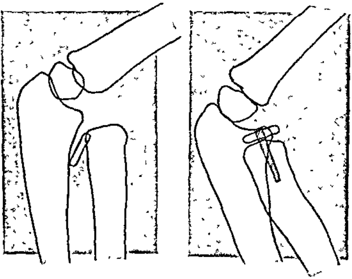

Fig 2382.—A. Fracture of the neck of the radius in childhood (separation of the epiphysis) with displacement. B. Open replacement and fixation with centrally placed bone peg.

After closure, splinting is employed for two to three weeks, after which active exercises are started.

In the case of children, fixation is more difficult. It is carried out by driving a bone peg through the articular surface of the head and up the shaft, so that at the end of the operation the peg is entirely extra-articular (fig. 2382). There is a minimum of damage to articular cartilage. In children, owing to the temporary separation of the head from its blood supply, the X-ray picture will show changes in the epiphysis subsequent to replacement. After a number of months, re-consolidation of the epiphysis will occur and usually the bone peg is absorbed.

Removal of the head of the radius should be avoided in a child, as it may be followed by cubitus valgus of an extreme degree and complicated by limited wrist movement, radial deviation of the hand, and

prominence of the head of the ulna. The operation in an adult is discussed later.

(iv) When the head is comminuted and displaced, removal of all the fragments and trimming of the upper end of the shaft is indicated. My own preference is to put the arm at rest and to remove the mass of bone some weeks after the injury.

(2) *Fractures of the Ulna.* (*a*) *The olecranon process* may be fractured transversely or there may be a stellate or comminuted fracture. It is caused by a fall or blow on the point of the elbow. When there is no separation, there is tenderness and bruising with pain on flexion and extension. In the case of separation. the diagnosis is made easy by the gap which can be felt between the two fragments.

Treatment. When there is no separation and in elderly patients, a light plaster trough is bandaged to the back of the arm and forearm, the elbow being placed at a right angle During setting, pressure is applied to compress the olecranon down on to the shaft as far as possible. This is not removed for three weeks. It is then taken off for exercises, but worn for six weeks altogether. This position is employed because the arm is very uncomfortable when left for three weeks with the elbow straight and because there is swelling of the hand. If the splinting is applied early, no separation occurs in the cases with no traumatic separation, and in elderly patients with separation this can be largely overcome. A stellate fracture is treated in a similar manner. When there is a transverse fracture with separation in a patient otherwise fit, open operation is advisable during the first week after injury.

The incision should be planned so that the scar is on the posterior part of the arm and the outer surface of the forearm. Half-a-horseshoe-shaped incision is suitable, the top of the incision being 1 inch above the olecranon. The fracture is exposed and blood clot removed. The aponeurosis, which is turned in over the fractured surface, should be elevated so that the bony fragments can be brought into accurate apposition. It is important to realise that accuracy of the line of articular cartilage is the chief requirement and that this will only be obtained if the posterior border of the bone is corrected absolutely.

Fixation is necessary. This can be carried out by:

(i) Suture of the aponeurosis and triceps round the fracture line;

(ii) Drilling holes and passing catgut or other absorbable material through them:

(iii) Passing wire through drill holes;

(iv) Drilling the lower fragment to take thick catgut, and fixing it

through the triceps or round a notch cut in the surface of the upper fragment;

(v) Drilling a hole through the olecranon from above, and driving a 2-inch screw through this and down the shaft of the ulna. This has the advantage that it tends to press the olecranon down on to the shaft firmly and there is no doubt about accurate and firm fixation. Hence, this is the method of choice.

The limb is put at rest at a right angle in a plaster trough for six weeks. Movement can be started after five to six weeks.

(b) *The coronoid process* is rarely broken, and then usually as a complication of a posterior dislocation of the elbow joint. Easy reduction or easy re-dislocation is suggestive of the injury. The fragment can rarely be felt.

Treatment consists in reduction of the dislocation, placing the elbow in full flexion and treating the case as a supracondylar fracture.

Prognosis after Elbow Joint Injuries

When there has been a fracture with no displacement, or a perfect reposition after a displacement, in a patient under forty, normal function should be obtained with rest in the correct position and active exercises. Too forcible manipulation, tight bandaging, or the employment of massage may be followed by disastrous complications which are avoidable.

The prognosis is less good when precise reposition is not obtained. *In children, cubitus valgus or varus may result, together with limitation* of movement. These children have good function without full movement. Osteo-arthritis will develop in middle life.

When an open operation is employed, accurate reposition may produce a normal elbow, especially if the operation is performed during the week following the injury. Although osteo-arthritis may never develop, any joint is liable to this condition later in life if it has been opened. In a few cases osteo-arthritis may arise a few years after the operation, even though it has been carried out under ideal conditions and with due care and deftness. When open operation has been performed and the bones not accurately aligned, osteo-arthritis usually occurs early.

Employment of internal fixation near the articular cartilage is followed by a greater limitation of movement and earlier arthritis than when a nail or screw is placed at a greater distance from the joint surface.

Following removal of the head of the radius in an adult, the patient often complains of a weakness of the hand. Extension is usually limited by 20 degrees, but other movements are full. I have seen full range of movement now and again and in some cases limitation of supination.

If it is conceivable that by means of rest and physical treatment an elderly patient with a fracture into the elbow joint will get 90 degrees of flexion and extension and most of the supination range, this should be employed in preference to any operative interference.

ULNA

Shaft. This occurs more commonly in children than in adults, and is due to a fall on the forearm. There is bruising and tenderness at the site of the fracture.

Treatment. (1) *Without displacement.* The hand, forearm, and lower half of the arm should be put into plaster with the forearm

Fig. 2383.—Plaster splint employed in fractures of the shaft of the radius and ulna.

supinated (fig. 2383). Six weeks' immobilisation is required. In the case of fracture in the lower third, a skiagram should be taken at the end of this time as delay in union is common in adults.

(2) *With displacement.* Although displacement is uncommon without fracture of the radius, when present it can be reduced to some extent by traction and manipulation, but there is a tendency to forward tilting of the upper fragment. Immobilisation in plaster is indicated, as in undisplaced fracture.

(3) *Fracture of the shaft of the ulna with dislocation of the head of the radius.* This combined lesion occurs in children usually about the age of six and rarely in adults. It is due to a severe fall on the elbow. There is an oblique fracture of the shaft of the ulna, above the middle

and usually at the junction of the middle and upper thirds. The line of fracture is downwards and forwards, and the upper fragment is flexed so that, in the lateral skiagram, it lies half to three-quarters of an inch in front of the lower fragment. The head of the radius is dislocated forwards ; it can be felt above the capitellum and no longer articulates with the lesser sigmoid fossa of the ulna. This dislocation is frequently not recognised at the time of the injury. It should be regarded as a serious injury.

Treatment. An anæsthetic is given. Traction is employed on the forearm whilst the arm is fixed. The fracture of the ulna is made loose and pressure applied to the front of the upper end of the radius. Reduction of the dislocation should be palpable. If the head stays in place, the elbow is flexed and a skiagram taken to see if the head of the radius is in its correct position. If so, the arm is fixed in this position and the injury is treated on the same lines as a reduced supracondylar fracture.

The reduction and fixation may be simple if carried out within forty-eight hours of the injury. On the other hand, recurrence of the dislocation may occur readily so that the head will not stay in its correct position. If the ulna cannot be pulled out to its normal length, reduction will not be possible. This is sometimes the case shortly after the injury, and invariably so if union of the ulna occurs before reduction of the dislocation, as the radius is proportionately too long for the ulna, and there is also overlap and flexion of the upper fragment.

When reduction of the dislocation is not possible, open operation is advisable. This consists in exposure of the site of the fracture of the ulna. This is freed and made loose, an osteotomy being carried out if necessary. An attempt is then made to reduce the head of the radius without exposing it. If this succeeds, the ulna must be fixed by a plate or peg to ensure that it is straight and of its full length. If the head of the radius is not reducible after exposure of the ulna, an incision is made over it and tight capsular structures are divided before reduction. The ulna is then fixed as described. The elbow should be put up at a right angle in plaster after the operation.

RADIUS

Shaft. Fractures of the shaft with an intact ulna are not common. Greenstick fracture is seen in children. In adults, the middle and lower portions of the radius are those most commonly injured. In fracture *of the middle of the shaft just below the insertion of pronator radii* teres, if there is no displacement, the forearm and lower half of the arm

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are put in plaster with the forearm supinated. The bone may take eight weeks to join. When there is displacement, it is necessary to correct this to make certain that the full range of pronation and supination is obtained. A manipulation does not always succeed. Under anæsthesia, forcible long-axis traction is employed with the elbow in a position of extension. Fixation in plaster is employed with the elbow bent to a right angle, for fixation in extension leads to swelling of the hand, is uncomfortable, and seldom holds the fragments better than in the position recommended. Failure of this method necessitates open reduction. The fractured area is exposed, and after clearing intervening structures the fragments are brought into normal alignment. If the operation is carried out a few days after the injury, no internal fixation is necessary as a rule. Late open reposition must be followed by internal fixation with a plate or intra-medullary fixation. After the operation, a plaster is employed. Eight or ten weeks may be required for union.

Fracture of the shaft in the region of the pronator quadratus results from the same causes as the Colles' fracture, particularly from a backfire. It is treated in a similar manner. Rarely is reposition impossible, except when there is an injury to the ulna above the head or epiphysis. In these rare cases, an open reposition of both fragments may be required.

Radius and Ulna

Fracture of the shafts of both radius and ulna is a common injury in children and not infrequent in young adults from heavy falls on the forearm, and in machinery and motor accidents.

Greenstick fracture. (*a*) *Without displacement.* A plaster splint is applied from the middle of the arm, and over the forearm to the palm of the hand, with a turn round the cleft between the thumb and first finger (see fig. 2383). It is left on for four weeks in children under six and for six weeks after that age. (*b*) *With angulation.* An anæsthetic is given, and the bones are cracked through and then placed straight. A plaster is applied as above. During the setting of the plaster a groove is moulded in the long axis of the limb between the two bones. If the bones are not cracked through, the angulation will tend to recur.

Transverse or oblique fracture with no displacement is treated in plaster as described. When there is displacement, there is usually pronation of the lower radial fragment, in addition to overlap of one or both bones. An anæsthetic is given, and strong long-axis traction is employed with the forearm supinated, assisted by digital manipulation. This succeeds more often in patients of adolescent age than in adults.

If the bones appear to have hitched, a plaster is applied as for the other forearm fractures. Lateral and antero-posterior X-ray pictures are taken to see if the position is satisfactory.

The setting of these fractures is often very difficult. If the traction has obviously not hitched the bones, an attempt can be made by bending the forearm at the site of the fracture and then attempting to lift the lower fragments on to the upper ends of the bone. This may be dangerous, and is only likely to be successful within forty-eight hours of the injury. Failure by manipulation necessitates open operation. When the line of fracture is transverse or approximately so, reposition without fixation will suffice, as an interlock will generally occur, sufficient to be held by plaster fixation.

When the fracture line is oblique, internal fixation is necessary in the radius, such as a plate or intra-medullary fixation, but it is unnecessary to fix the ulna even if it has to be exposed. In the case of fracture of the upper third of the radius, internal fixation is usually advisable.

In all fractures of the shafts of the radius and ulna, except greenstick fractures, a skiagram should be taken when the plaster is removed. A number are not united in six weeks, and re-fracture following a trivial injury is prone to occur, particularly in children about ten years old.

The fingers can be moved freely with the plaster *in situ*. Elbow movements quickly return when the plaster is removed, and pronation and supination are freed by exercise and use.

Cross union will not occur if the bones are properly aligned and the forearm placed in supination. The grooving of the plaster during its setting is an additional prevention of this.

FRACTURES ABOUT THE LOWER END OF THE RADIUS

COLLES' FRACTURE

This is a fracture of the lower end of the radius, ½-inch above the wrist joint. The anterior surface of the radius is broken at a lower level than the posterior surface. The fracture is most commonly seen in women over forty years of age, and is frequently comminuted in elderly persons.

Additional fractures are often associated: (1) Ulnar styloid process, torn off by pull of internal lateral ligament. The process seldom unites by bony union; (2) T-shaped or Y-shaped crack running into the wrist joint.

Deformity. This is due almost entirely to the causative violence,

which is invariably applied to the thenar eminence by a fall on the outstretched hand. As a result, the lower small fragment is driven backwards and impacted on the radial or external side.

Diagnosis. Special attention should be directed to the site of local tenderness over the lower end of the radius, to pain on gripping, and to the relation of the ulnar and radial styloid processes to one another. When there is displacement the classical "dinner-fork" deformity is obvious. Many "sprained" wrists are in reality Colles' fractures with impaction and no displacement.

X-ray examination. In viewing the films of a Colles' fracture certain points should be taken into consideration, with a view to prognosis and treatment:

(1) *Antero-posterior view:* (*a*) The degree of radial tilting and radial impaction; (*b*) The presence of fracture of the ulnar styloid process; (*c*) Whether the fracture line runs into the radio-ulnar joint, or is above it; and (*d*) Whether the fracture is comminuted and involves the wrist joint.

(2) *Lateral view:* (*a*) Backward displacement of the lower fragment; (*b*) Backward *tilt* of the lower fragment. As a result the joint surface ceases to be at right angles with the shaft of the bone. The backward tilt is of special importance for, if not corrected, instability of the wrist joint and weakness of grip will result.

Treatment. Except in extreme senility, every recent case of Colles' fracture should be treated actively and an attempt made to reduce deformity and fix the fragments.

Aims. Although perfect anatomical alignment is desirable and usually obtainable, certain cases of severe comminution prevent this perfection. It is essential to correct *backward tilt* and radial deviation. If some degree of backward displacement of the lower fragment persists, a reasonable functional result will follow, provided the tilt has been corrected.

Technique of Reduction. Colles' fracture may be corrected with deliberation and care under nitrous-oxide anæsthesia. This probably forms the ideal anæsthetic for the fracture, as it gives a sufficiently long period of relaxation, is a much more rapid method than local anæsthesia, and avoids the risk of sepsis. Local anæsthesia gives good results when used in organised fracture clinics, but for general casualty work N_2O has obvious advantages.

The fracture is disimpacted by increasing the deformity in the following manner: The surgeon stands facing the patient and grasps the injured wrist between his thenar eminences. The fingers of the

"palmar" hand grip the ulnar border of the patient's hand. Pressure by the "palmar" hand increases the deformity and a slight wriggle will complete the disimpaction. The position of the surgeon's hands is now reversed. The "dorsal" hand presses on the lower fragment, while counter-pressure is made by the "palmar" hand on the lower third of the forearm. The lower fragment is thus carried palmarwards

Fig. 2384.—COLLES' FRACTURE (COMMINUTED)

The upper films show: (1) Backward and upward displacement and tilting; (2) comminution of the fragment, so that the radial styloid is separated from the other piece of the lower fragment. The lower films show the same fracture immediately after setting.

and into ulnar deviation. In difficult cases the lower fragment may be pushed forwards over a wedge. Usually, however, the reduction is comparatively easy and can be carried out in three distinct steps: (1) Increase of deformity followed by disimpaction; (2) Correction of backward displacement and backward tilt; and (3) Ulnar deviation.

Failure to obtain complete disimpaction is a frequent cause of faulty setting.

In "late" cases, an attempt should be made to correct deformity up to 10 days. After this time, correction by open operation may be necessary.

Fixation.

(1) *By Carr's splint.* The splint is padded with felt. A thick felt pad is attached to the splint by strapping, so that it lies beneath the wrist joint. It should be $\frac{3}{4}$-inch thick, its function being to produce slight palmar-flexion of the wrist. The bar of the splint should be well "home" in the web of the thumb, and the hand well deviated to the ulnar side. The splint is fixed by two strips of $1\frac{1}{2}$-inch strapping, one applied in the upper third of the forearm, and the other across the dorsal aspect of the wrist joint *below* the fracture. It is well to pass the strapping over small felt pads, or blistering of the skin may be caused. Finally, a firm calico bandage is applied. This should commence from

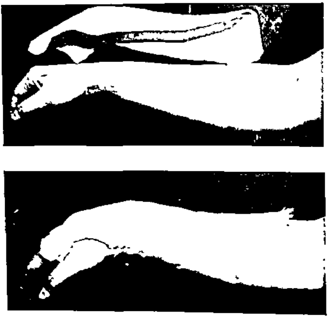

Fig. 2385.—Showing dorsal plaster-cast for Colles' fracture and method of fixation by flannel bandage.

without inwards across the dorsum of the forearm; when the wrist is reached, a loop of bandage is taken round the bar of the splint and returned across the dorsum in the opposite direction. The bandage is then finished off in the usual manner. The loop serves to maintain the hand in ulnar deviation.

(2) *Fixation by plaster.* Instead of Carr's splint, fixation may be made by an unpadded dorsal plaster slab. The slab should cover the whole of the dorsal aspect of the forearm and extend to the knuckles (fig. 2385). The wrist is held in ulnar deviation and slight palmar-flexion while the cast is hardening. A turn of plaster bandage or a loop of wire should pass across the palm. It should be narrow so that free movement of the fingers and thumb can take place. The slab is retained by a covering of flannel bandage, over which is applied one layer of wet plaster bandage.

After-Treatment.

General. The patient is told to move the shoulder, fingers and thumb from the first, and should be encouraged to make as much use of them as possible to grasp light objects or in attempts to play the piano. This will be much easier when the plaster-cast is used.

An arm sling may be necessary to make the patient comfortable for a few days, but it should be discarded as early as possible. Neglect of this leads to inadequate finger movements and to stiffness of the shoulder joint, which is a common and unrecognised complication of Colles' fracture.

Special. (1) If a Carr splint is used, it should remain undisturbed for ten days. Massage is then started. The bandage and strapping are removed, but the limb remains on the splint. Gentle massage and assisted finger movements are employed. Attention should also be given to the elbow and shoulder.

At the end of three weeks the splint may usually be discarded; if all local tenderness has disappeared, movements of the wrist joint may then be commenced.

(2) The plaster-cast should remain undisturbed for four or five weeks. Active use of the limb is encouraged, and when confidence is gained more household duties can be performed.

Subsequent treatment consists in the wearing of a firm wrist bandage, and in physio-therapy if free movement does not return quickly.

Common Mistakes.

(1) Fracture not completely reduced before splint is applied (fig. 2386); (2) Neglect to make an X-ray examination after reduction;

Fig 2386.—Skiagram of Colles' fracture. Imperfect reduction. Note backward tilt of the lower fragment.

Fig 2387.—Malunion in Colles' fracture, with impaction and severe backward tilt of lower fragment.

(3) Removal of splint too early, when callus is still soft; (4) Violent massage and movements which cause deformity to recur; and (5) Badly-applied splint or plaster resulting in: (*a*) Blistering of the skin and œdema; and (*b*) Limitation of finger and thumb movements.

Common Complications.

(1) Malunion (see fig. 2387).

(2) Tenosynovitis of extensor tendons.

(3) Arthritis of wrist and radio-ulnar joints.

(4) Stiff elbow and shoulder.

A rare complication is *rupture* of the *extensor pollicis longus tendon*, which may occur at any time between a week and many years after the injury. (See also Vol. II, page 3457.)

The rupture is more frequently found when early active movements of the thumb have been instituted, which lends support to the view that the tendon is traumatised against a sharp bony spicule.

BACKFIRE FRACTURE

The cause is a backfire while swinging the engine of a motor vehicle, hence the fracture is seen almost exclusively in young male adults.

It may happen in two ways:

(1) The starting-handle is grasped between the fingers and thumb. The sudden jerk is transferred to the region of the lower end of the radius.

Three types of fracture may result:

(*a*) Colles' fracture

(*b*) Oblique fracture into the wrist joint from the base of the styloid process.

(*c*) Fracture of radius 1 to 3 inches above the wrist joint.

(2) The starting-handle is grasped with the fingers only. The jerk forces the handle out of the grasp of the fingers and the handle flies round, striking the dorsal aspect of the forearm in the lower third. The site of fracture will be at this level.

SMITH'S FRACTURE

A reversed Colles' fracture. The displacement of the lower fragment is forwards instead of backwards.

SEPARATED LOWER RADIAL EPIPHYSIS

A common injury among adolescent males. The cause is a fall on to the outstretched hand, and the condition corresponds with a Colles' fracture in later life. It is sometimes bilateral.

The lesion is a fracture-dislocation of the epiphysis, the fracture

consisting of a small triangular fragment broken from the dorsal aspect of the radius and remaining attached to the epiphysis.

Deformity is similar to that of a Colles' fracture (fig. 2388).

Treatment. The small fragment of radial shaft makes the reduction of the separated epiphysis difficult.

Should manipulation fail, forcible correction over a wedge will nearly always succeed, provided this is attempted early. Fixation is by a plaster-cast. If any backward tilt persists after attempted reduction, the wrist should be put into full palmar-flexion and ulnar deviation.

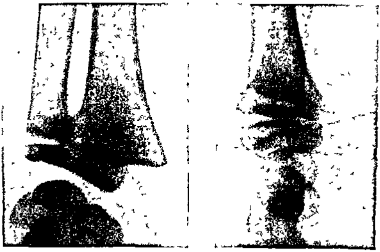

Fig 2388.—SKIAGRAMS SHOWING SEPARATED EPIPHYSIS OF LOWER END OF RADIUS WITH FLAKE TORN OFF LOWER END OF DIAPHYSIS. LATERAL VIEWS SHOWING DISPLACEMENT AND REPOSITION AFTER MANIPULATION

Open operation is inadvisable because of the danger of damaging the epiphysial line and thus interfering with bone growth, but in old-standing unreduced cases an osteotomy may be required.

CARPAL BONES

SCAPHOID

This is a common injury which is frequently misdiagnosed as a "sprain" of the wrist (see fig. 2389). Every "sprain" should be subjected to X-ray examination. The bone fractures in its narrow central portion, and the use of a lens may be necessary to see the fracture line in the skiagram. Some weeks after the injury the fracture line becomes wide and obvious owing to separation of the fragments, absorption of bone, and decalcification. Fixation must be maintained for a long time, as otherwise the newly-formed blood-vessels will be torn across by movement and non-union will result.

Diagnosis. History of a fall on the hand or of a sudden jerk, pain, swelling, and tenderness on pressure in the "anatomical snuff-box" and over the tuberosity of the scaphoid, at the base of the thenar eminence; there is, in addition, limited dorsiflexion of the wrist.

Treatment.

(1) *Recent cases.* The wrist is fixed in full dorsiflexion by means of a plaster-cast. The cast should be removed at the end of six weeks and X-ray pictures then taken. If bony union is not complete, the cast is reapplied for a further four weeks.

(2) *Late cases.* If the injury has remained untreated for some weeks, the scaphoid will appear decalcified. This irregular decalcification is referred to as "cavitation." One of the fragments may appear denser than the other, as a result of diminished blood supply.

A plaster-cast is applied as before, but a much longer period of

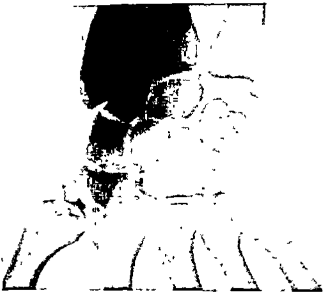

Fig. 2389.—Skiagram showing fracture of the scaphoid.

immobilisation will be required—as long as eight months may be necessary. Active use of the arm, fingers and thumb must be encouraged during the period of immobility.

(3) In *very late untreated cases*, the fracture surfaces may appear sclerosed, as in other bones in which non-union is present. It is useless to expect this type to unite by immobilisation, unless the fragments are first drilled by Beck's method to provide channels through which blood-vessels may grow.

(4) The *operation of removal* of the scaphoid or of a fragment is sometimes advocated. The result of this procedure is poor, arthritis and weak grip being frequent sequelæ.

SEMILUNAR BONE

Dislocation of the semilunar bone is found occasionally, as a result of falls and blows upon the outstretched hand. The mechanism by

which the dislocation is produced may be described in three stages:

(1) Dorsal dislocation of the hand, upon the semilunar and radius.
(2) Upward displacement of the hand, so that the head of the os magnum lies behind the semilunar. The weak posterior ligament between the radius and semilunar gives way and the bone starts to rotate forward as it is pressed upon by the os magnum.

Fig. 2390.—Skiagram showing dislocation of the semilunar bone. Note that the bone has been pushed forwards and rotated by the os magnum.

(3) The semilunar rotates through 90 degrees, so that its concave surface looks forward and the head of the os magnum articulates with the radius. On occasions, the semilunar may rotate further on the anterior ligament, so that it rests on the anterior surface of the lower end of the radius, the concavity of the bone facing the elbow.

Diagnosis. History of injury, limited movement in the wrist (especially flexion), and effusion. In recent cases the bone may be felt on the front of the wrist as an indistinct swelling. Tingling in the distribution of the median nerve may be present.

X-ray examination. The lateral view is the more important, and shows the bone lying in front of the os magnum, with its crescentic margin looking forward (fig. 2390).

Complications.

(1) The scaphoid may be fractured in addition. If this is so, the inner fragment will be found dislocated forward with the semilunar.

(2) One of the "horns" of the semilunar may be fractured, usually the posterior.

(3) The injury is liable to be misdiagnosed in the absence of X-ray pictures. Old-standing dislocations are difficult to reduce and may necessitate open operation.

Treatment.

(1) *Recent cases.* Reduction is effected by manual traction, under anæsthesia, on the fingers and thumb. Counter-traction is made on the forearm by an assistant, or the method of fixing the flexed elbow to a wall hook by means of a webbing sling, as advocated by Böhler, may be used. The traction is kept up steadily for at least ten minutes, but this alone does not reduce the dislocation; pressure upon the dorsal aspect of the wrist will cause the os magnum to snap back into place, provided the dislocation is in Stage (1).

A skiagram is taken, confirming that reduction is complete. If the method fails, a second attempt should be made. In any case, the widening of the gap between radius and os magnum will render the subsequent operation easy.

(2) *Open operation* is only indicated where traction has failed. The interval between radius and os magnum is exposed by a straight incision on the dorsal aspect, on the side of the radial tubercle. The tendons are retracted and the head of the os magnum levered back into position. Approach from the front of the wrist is referred to later.

Fixation. This is by dorsal plaster slab for three weeks. If the scaphoid is fractured, fixation must be for eight weeks. X-ray examination at the end of this period should confirm bony union, otherwise the period of fixation must be extended. Subsequent massage is unnecessary.

Removal of the semilunar leads to a weak wrist and grip and should be avoided.

Note. Kienboch's disease is an affection of the semilunar bone causing necrosis of unknown pathology. It is not related to dislocations, but may result from compression fracture on this bone.

OTHER CARPAL BONES

These are treated by the application of a plaster-cast, with the wrist in dorsiflexion. Fixation for three to six weeks is required. Active use of the arm and fingers should be encouraged.

METACARPALS

Bennett's fracture. The so-called boxer's fracture is a fracture-dislocation of the base of the first metacarpal. The shaft is displaced in

a radio-dorsal direction, while a small triangular fragment remains in its normal relation to the trapezium on the ulnar palmar side. As the joint between the metacarpal and trapezium is of special importance in movements of the thumb, accurate reduction is essential. A comparable injury occurs before the epiphysis at the base of the first metacarpal has fused. The proximal fragment consists of the epiphysis and a wedge-shaped piece of bone.

Treatment. The patient is anæsthetised. The surgeon grasps the wrist with one hand and exerts powerful traction upon the thumb with the other. The prominent base of the metacarpal is then pushed back into position and the thumb fully abducted.

Fixation. A complete plaster-cast is applied to the forearm and extends to the knuckles. It continues as a "sleeve" to the tip of the thumb. It is advisable to place a small piece of felt over the base of the metacarpal. While the plaster is setting, the thumb is held in full abduction, and the plaster is moulded firmly over the site of fracture, which is protected from undue pressure by the felt.

The cast should be kept in position for three weeks. Should manipulative reduction fail, resort must be had to skeletal traction, as described subsequently.

Fractures of 2nd to 5th Metacarpals.

The fracture may be of the base, neck, or shaft. The former are commonly transverse, while the latter is an oblique fracture. Fracture of the neck of the 5th metacarpal bone is common. The shafts of several metacarpal bones are not infrequently fractured by the same injury. Deformity, if present, consists of overlap, with antero-posterior or lateral displacement.

Diagnosis. Local tenderness, inequality of the knuckles when the hand is clenched, and pain on finger movement. A useful sign is elicited by pulling on the fingers, or by pressure on the knuckles. If these cause pain, a fracture is almost certainly present. Skiagrams, of course, are essential.

Treatment.

(1) *Fracture without displacement.* Fixation by a padded malleable iron splint, applied on the dorsal or palmar aspect of the metacarpal and corresponding finger, is all that is necessary. Four weeks will be required for union.

(2) *Fractures with displacement.* Continuous traction must be applied until the fracture is united.

Method. An anæsthetic is given. The forearm is encased in a well-fitting plaster-cast, extending from below the elbow to the knuckles.

While the plaster is setting, an assistant makes traction on the fingers and the displacement is corrected as much as possible by manipulation. That portion of plaster over the site of fracture is well moulded. A piece of malleable iron or stout iron wire is fastened to the plaster-cast by a few turns of plaster bandage in such a way that it projects beyond the finger. The end of the wire is bent into a hook. The traction apparatus on the finger is now connected to the wire hook by a piece of tape or elastic. The line of traction should cause the finger to be semi-flexed. Continuous traction may be kept up in this way for an indefinite period. Daily inspection is necessary to maintain the correct degree of traction. Four weeks' traction will usually suffice. This method is particularly valuable in the treatment of open fractures. Extension is made from the corresponding finger in one of the following ways:

(*a*) *By adhesive strapping.* A piece of 1-inch strapping, twice the length of the finger, is folded at the centre over a piece of string. The

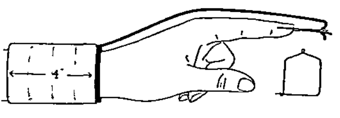

Fig. 2391.—Apparatus for treating fractures of the metacarpus or phalanges. Plaster-cast round wrist incorporates malleable wire extending beyond a finger. A wire clip (inset) has been inserted through the pulp of the finger and an extension tape is attached to this and to the wire.

two "limbs" thus made are attached to the lateral aspects of the finger and bound firmly by ¼-inch oblique strips. Considerable traction may be exerted in this way.

(*b*) By a spring wire clip, inserted into the pulp of the finger (fig. 2391).

(*c*) By transfixion of the nail and terminal phalanx with a short length of Kirschner wire. The wire is then bent into a loop and twisted together.

DISLOCATION OF THE PHALANGES

Simple traction is sufficient to overcome the majority of these dislocations.

Dislocation of the metacarpo-phalangeal joint of the thumb may be difficult to reduce, owing to the interlocking of the flexor tendons or joint capsule with the head of the metacarpal. Should manipulation fail, an incision is made over the flexor aspect and the tendons drawn aside. Reduction is then easy.

FRACTURES OF THE PHALANGES

Proximal. The proximal fragment becomes flexed and the distal fragment hyperextended by the action of the lumbricales and interossei muscles.

Treatment. The deformity can often be corrected by manipulation, and the finger immobilised in a position of flexion on a malleable iron splint applied to the palmar aspect. Failing this, one of the methods of traction advised for fractures of the metacarpal bones should be employed. The malleable iron splint should be incorporated in the plaster-cast or malleable wire be placed on the dorsum, and continuous traction made while the finger rests upon it (see fig. 2391). Four weeks will suffice. Active exercise of the sound fingers must commence at once.

Fractures of the middle and terminal phalanges. Displacement should be reduced and the finger immobilised on a malleable iron splint for three weeks.

Transverse fracture of the terminal phalanx often remains untreated, and fibrous union or non-union may result, with no disability.

Fractures with joint involvement. These occur as a result of blows upon the tip of the extended finger. Treatment is on general lines. Dislocations are reduced by manipulation, but occasionally open operation is required owing to displaced bone fragments. Limited movement frequently follows fractures into an interphalangeal joint.

Avulsion of a bone fragment at the insertion of the extensor tendon is sometimes seen. The result is a "mallet finger." Treatment is by fixation on a malleable iron splint or by plaster for six weeks. When fixed, the finger should be flexed at the middle joint and extended at the terminal joint. This position brings about relaxation of the extensor tendon (see also Vol. II, page 3448).

Multiple fractures of metacarpal bones and phalanges are best treated by extension on all the fingers. A plaster-cast is applied round the forearm. A hoop of wire with two 6-inch arms is made. The hoop extends round the ends of the fingers and 2 inches beyond. The arms are fixed in the plaster-cast. The extensions are attached to the hoop. The extensions can be by strapping, or by pin extension inserted through the terminal phalanges or through the pulp of the fingers.

RIBS

Fractures result from direct violence or compression. It is common to see one or two ribs broken in the middle, or a large number just in front of the angles, when there are other severe injuries. In the

elderly, fracture of one or two ribs is relatively common, whereas in children it is rare. except in severe road accidents in association with other injuries.

Signs and Symptoms. There is severe pain over the fracture which is increased by deep breathing and coughing. Crepitus may be felt and local tenderness. Displacement is seldom present. Pain is produced at the site of the fracture by compression of the chest wall.

Complications result from injury to thoracic viscera, particularly to the pleura and lungs in the upper ribs, and to the liver and kidneys below. The signs of surgical emphysema will be evident, and those of visceral injury are usually more prominent than those of fracture. Compound fractures are readily diagnosed by inspection of the wound, and often extend to the pleura.

Treatment. When no complication exists and the patient is fit, confinement to bed is not necessary. After forced expiration, the chest is strapped for two-thirds of its circumference, so that two ribs above and below the injured ones are covered. This should be retained for three weeks.

Prognosis. No permanent injury results from an uncomplicated case. Pain is often very persistent, particularly in a heavily-built man. Ordinary light occupation can be followed soon after the injury in most cases, but a man employed on heavy labour should be kept off work for three months. Prolonged fixation appears to assist this type of case.

Pneumonia may follow in the aged, and this complication at any age is likely to be more serious than the fracture itself.

STERNUM

Fracture is rare and is due to a severe crush. Sometimes it occurs at the same time as a flexion-fracture of the dorsal spine. There is usually hæmorrhage into the anterior mediastinum. Examination shows a bruise and tenderness over the site of the injury. Displacement is palpable, particularly when the manubrium is displaced backwards in relation to the body of the sternum. Thoracic viscera may be injured. Treatment consists in putting the patient to bed for a month with a back-rest. Local treatment is not necessary. No manual work should be allowed for two months.

SPINE

The majority of these fractures are caused by *indirect violence*, such as falling from a height on to the buttocks, or by a heavy weight

falling on to the back while the patient is stooping. Fractures produced in this manner are almost always of the compression type. *Direct violence* and muscular actions also play a part, the former being responsible for fractures of spinous processes, transverse processes, and the rare condition of fracture of a lamina. It has been pointed out (S. T. Irwin, *B.M.J.*, Jan. 4th, 1936) that fracture of the transverse processes, so common in the lumbar region, is probably caused by the pull of the quadratus lumborum muscle rather than by direct violence.

A convenient *classification* of spinal fractures is the following:

(*a*) Compression fractures of a vertebral body, 40 per cent.
(*b*) Fracture of spinous process, transverse process or lamina.
(*c*) Fracture-dislocation in the cervical region.
(*d*) Fractures of special vertebræ (atlas and axis).
(*e*) Fracture of the coccyx.

Site. Compression fractures occur most frequently in the dorsi-lumbar region of the column (10th dorsal to 2nd lumbar). Fracture of transverse processes in the lumbar region, and fracture-dislocation in the cervical (commonly 5–6th cervical). Fractures in the upper dorsal region are rare, owing to the support given by the ribs.

Diagnosis. This is usually straightforward if it is remembered that every suspected case of spinal injury must be examined by X-rays, both in the antero-posterior and lateral planes. Occasionally a stereoscopic view may be of service in the cervical region. Considerable deformity may occur, but spontaneous reduction may take place whilst the patient is being transported to hospital, and unless the skiagrams are carefully examined the fracture may be missed. Such cases probably explain the slow collapse which may be discovered in a vertebral body some months after what appeared to be a trivial injury. This condition has been described under the name of *Kümmel's disease* (spondylitis traumatica).

(*A*) *Compression Fractures*

This type is the result of acute flexion of the spinal column. The mid-dorsal region is occasionally involved. Only 30 per cent of cases are complicated by severe cord or nerve injury. The natural tendency of this part of the column is to flex when under stress, and one vertebral body becomes "nipped" between the bodies of the vertebræ above and below (see fig. 2392). Owing to the spongy structure of a vertebral body the thin cortex of bone is easily broken through and the anterior portion of the bone is pushed forward, thus putting the anterior common ligament under tension. Damage to the intervening intervertebral

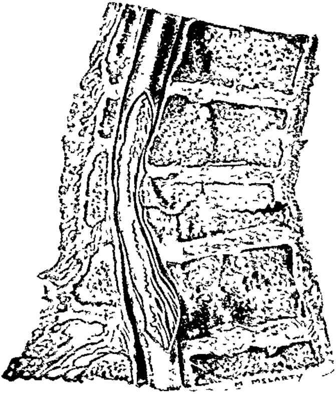

Fig. 2392.—Compression fracture of vertebral body. Note the wedging and increase of antero-posterior diameter.

(*Museum, King's College Hospital.*)

Fig. 2393.—Skiagram showing compression fracture of vertebral body caused by acute flexion.

discs may also occur and has been well described by Schmorl and Beadle (fig. 2393).

In cases where the spinal cord is injured, there may be compression followed by œdema, hæmorrhage into the cord, or complete transection (fig. 2392). Paraplegia will result in each case, but it is impossible to tell in the early stages how much recovery will take place.

Prognosis. This will depend upon: (*a*) Early diagnosis; (*b*) signs of cord injury; and (*c*) the efficiency of the treatment.

In the absence of cord injury, the prognosis is excellent provided that disimpaction and immobilisation for a sufficiently long period are carried out. Should the deformity remain unreduced, persistent pain and disability are to be expected.

Treatment. The deformity is reduced by the method advocated by Robert Jones and developed by Watson Jones (*Journ. Bone and Joint Surg.*, 1934, XVI, 30–45).

The principle is simple in that it consists of hyperextension of the spine. This is brought about by the patient's own weight and no extra force is required. The apparatus consists of two tables, one rather higher than the other. The patient lies prone, with his arms and shoulders resting upon the higher table and his legs upon the lower. The portion of his body between the clavicles and the groins is suspended in mid-air and "sags" down, thus producing sufficient hyperextension to complete reduction of the fracture. A preliminary injection of morphia ¼ gr. is given, but no anæsthetic is required and only slight pain and discomfort are experienced. It is convenient to provide a canvas sling round the upper part of the chest which is connected to a pulley on the wall behind, and thus relieves the arms of a considerable portion of the body weight.

In this position a *lightly*-padded plaster jacket is applied over a vest or bathing suit. A small felt pad should be placed in the lumbar region and the plaster well moulded round the pelvis. The jacket extends from the clavicles to the groins (see fig. 2394). A window is cut over the lumbar felt pad, but the felt is not disturbed.

The patient is returned to bed, but may sit up immediately and is allowed to walk in a week.

After-Treatment consists in encouraging a normal mode of life and in graduated exercises to the limbs, pelvis, and abdominal and spinal muscles. The jacket should be worn for a period of from three months in mild cases to six months for a severe comminuted fracture. The condition of consolidation of the fracture must be checked by skiagrams taken through the plaster before removal of the

jacket. Following upon removal of the jacket the patient continues his exercises and commences flexion of the spine.

Reduction of Special Spinal Fractures.

(1) *Dorsal region.* The spine is fixed just below the site of fracture by means of a sling tied to the table legs. Hyperextension by the shoulder sling then exerts great force at the site where it is required.

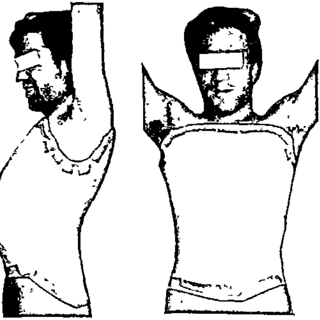

Fig. 2394.—PLASTER JACKET APPLIED FOR FRACTURE OF THE LOWER DORSAL SPINE.

Note. (*a*) A rare type of comminuted fracture is caused by hyperextension. It can be recognised in a lateral skiagram by the fact that the posterior part of the vertebral body remains intact while the anterior half separates into an upper and lower fragment In this type of fracture hyperextension is obviously contraindicated

(*b*) Some authors advocate that fractures occurring in the portion of the column where the convexity is backward (i.e. the upper-dorsal region) should be treated by reduction followed by recumbency in a plaster bed, owing to the tendency for the deformity to recur.

(2) *Cervical region.* The patient lies supine, with his head and shoulders projecting beyond the table. Hyperextension is effected by allowing the head to drop back. The plaster-cast is made to include the head, neck and upper trunk.

(3) *Late cases of crush fracture, with persistent pain.* In these cases, the question of fixation of the damaged vertebræ by a short Albee bone graft should be considered.

(4) *Fractures complicated by paraplegia* (fig. 2395). Immediate relief of pressure by hyperextension is indicated. Laminectomy is useless in the majority of cases, whether performed early or late.

The prognosis in fractures in the lower dorsal and lumbar regions is good, that in the upper dorsal region is poor.

First-Aid treatment (*when diagnosed by a doctor*). Arising out of these methods of treatment, it is obvious that when a patient is transported from the scene of accident he should lie in the *prone position.*

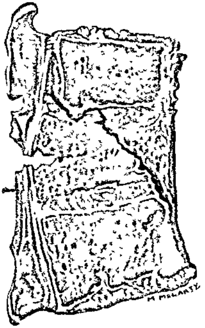

Fig. 2395.—OBLIQUE FRACTURE-DISLOCATION INVOLVING TWO VERTEBRÆ AND THE INTER-VERTEBRAL DISC. THE SPINAL CORD HAS BEEN DAMAGED (*Museum, King's College Hospital.*)

In many instances, carried in this way, the fracture is found to be reduced on arrival at hospital, although the presence of paraplegia may indicate that a serious deformity was at one time present.

(*B*) *Fractures of Spinous and Transverse Processes and of the Laminæ*

(1) *Spinous processes.* There are fractures by direct violence, muscular action, or hyperextension. The superficial processes of the lower cervical and upper dorsal region are prone to injury. Immobilisation for a few days, followed by physical treatment, is all that is necessary.

(2) *Transverse processes.* Those of the lumbar vertebræ are most often affected. Traction by the quadratus lumborum is often responsible, but direct violence accounts for a number of cases. Care should be taken not to mistake an un-united epiphysis for a fracture. This may be of medico-legal importance. As the majority of cases occur in labouring men, the period of disability is longer than might be expected and some pain may persist for as long as three months.

Treatment. It is advisable for the patient to rest in bed for fourteen days. The injured part may be firmly strapped over a piece of felt. Subsequently, physical treatment should be employed. The fragment should never be removed.

(3) *Lamina.* Pressure on the spinal cord may be present through bone being driven inwards by direct violence, or the fracture may be confined to a fissure. If any displacement is present, or if the cord is pressed upon, treatment should be by open operation, in order to remove depressed portions of bone or blood clot.

(C) *Fracture-Dislocations in the Cervical Region*

(1) *Above the 4th Segment.*

(*a*) *Simple dislocations* are usual, although an articular facet may be fractured. The cord is uninjured. If one articulation is dislocated, there will be rotation of the upper vertebræ upon the lower. If both

Fig 2396.—Skiagram showing fracture of the body of the fourth cervical vertebra with forward tilting of the vertebra above.

are dislocated. the upper vertebræ will be displaced forwards. Pain, stiffness of the neck. and accurate skiagrams will make the diagnosis clear (fig. 2396). The nerve-roots may be injured.

Treatment is by immediate manipulative reduction, if necessary under an anæsthetic. The manœuvres consist of extension, side flexion, and rotation, and reduction is often effected with a click. The neck is immobilised in a plaster collar for six weeks.

(*b*) *Fracture-dislocation* in this region results in sudden death from respiratory failure due to severe cord injury.

(2) *Below the 4th Segment—Cord Injured.*

Sudden death may occur, or if the phrenic nerves escape the patient may live. The prognosis is poor and the complications of

bed-sores, retention of urine and ascending pyelonephritis are inevitable.

(a) *Injury at level of 5th segment:* Complete paralysis of arms.

(b) *Injury at level of 5th and 6th segment:* Arms held in abduction, with elbows flexed and forearms supinated—" Kamerad " position.

(c) *Injury below 6th segment:* Partial paralysis of hand. The arms can be moved.

The level of the fracture may be localised by neurological examination (see page 5515).

Treatment. Should evidence of cord injury be present, without bony displacement, the spine is fixed by a plaster-cast, including the head, but no other treatment is instituted (Cotton).

If displacement is present, reduction should be attempted by manipulation, and the spine subsequently immobilised.

The *prognosis* in such cases is usually hopeless, the patient dying months or years later.

Cord Uninjured.

Reduction is effected by manipulation, or, should this fail, by gradual extension. This is applied by a leather " halter " which grasps the chin and occiput and to which a weight extension may be attached. Subsequently, immobilisation in a plaster collar for three months is advisable. The collar rests on the shoulder, to which it should be moulded, and fits accurately round the chin, lower jaw and occiput. For more secure fixation the plaster may be extended posteriorly to a band encircling the head.

(D) *Fractures of Special Vertebræ*

(1) *Atlas.* The force applied to the vertex of the skull tends to drive the occipital condyles into the condyles of the atlas. These face inwards and so the bone tends to be " spread " laterally. The posterior arch, being the weaker, is broken. Forty-five per cent of cases are non-fatal. The odontoid process of the axis may be fractured in cases where hyperextension of the neck has occurred.

Diagnosis depends upon the history, and upon inability to nod or to rotate or support the head without pain. Anæsthesia or neuralgia may be found in the distribution of the great occipital nerve. *Examination should include inspection of the spinous process for undue* prominence, and of the pharynx for projection of the lateral mass.

Treatment. In the presence of deformity, manipulation or extension may be attempted. Sudden death may result from displacement of the odontoid process against the cord; should this be fractured, careful X-ray examination must be made before attempting any

manipulation. Immobilisation, as for high cervical fractures, is advised.

(2) *Axis.* The common site is the base of the odontoid process. It is caused by acute hyperextension of the neck, or by pressure upon the head when the spine is held rigid. Union by bone is rare.

Treatment follows the general principles already outlined.

(*E*) *Fracture of the Coccyx*

A common accident, due to falls while descending the stairs, the coccyx being struck against a projection. (Coccygeal neuralgia is common among women after falls on the buttocks, but is not necessarily associated with a fracture.)

Diagnosis. Rectal examination should always be made; the coccyx can be grasped between the finger and thumb, and pain on movement, or deformity, be observed. Forward displacement may interfere with child-birth.

Treatment. This consists of: Reduction of any deformity by a finger in the rectum; rest in bed for fourteen days; and excision of the fragment or of the whole coccyx may sometimes be necessary.

PELVIS

There may be fractures of the true or false pelvis (i.e. above or below the pelvic brim), or of the sacrum, coccyx or acetabulum. The

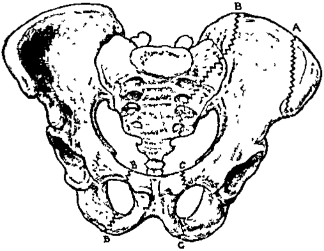

Fig 2397.—Illustrating types of fracture of the pelvis
A. Fracture of iliac crest
B B B. Oblique fracture.
C C. Fracture confined to pubis and ischium

cause is usually violence applied directly, either as a result of road accidents, falls from a height, or crush injuries. According to statistics (published in 1929) of 100 cases, 44 per cent involved the whole pelvic girdle, 24 per cent the pubis, and 18 per cent the ilium.

Types.

(1) *Fractures of the ilium* consist of linear or stellate cracks, causing separation of a portion of the iliac crest (fig. 2397, A). Crepitus is obtainable, and a large hæmatoma may be present in the iliac fossa. Visceral complications are rare.

Avulsion of the anterior superior or inferior iliac spine may occur as a result of muscular traction.

(2) *Fractures of the pubis ;* both rami were accompanied by visceral complications in about 20 per cent of cases.

(3) *Fractures of the whole pelvic girdle.* Two types are common :

(*a*) An oblique fracture running through the ilium and sacral foramina on one side, with a fracture of the pubis and ischium on the opposite side (see fig. 2397, B–B–B).

(*b*) The fractures of ilium, sacrum and pubis may be limited to one side only.

Complications. Either type may be associated with injury to viscera, and, in the series quoted, rather more than 10 per cent sustained this complication. In every case in which injury to viscera occurred, of whatever type, the accident was due to being run over in the street.

(*a*) *The membranous urethra may be torn.* Signs of this should be sought in every case in which the pubic bones are involved. Pain, retention of urine, and perineal hæmatoma are typical symptoms. Blood may be "milked" from the urethra. If doubt exists, a soft rubber catheter should be passed and a specimen of urine obtained. Great care must be taken to avoid infection, and the catheterisation is best done in the operating theatre, rather than in the casualty department. On no account should the patient be told to "see if he can pass water," as in the presence of a tear extravasation of urine will result.

(*b*) *Rupture of the bladder.* Intra- or extra-peritoneal rupture may occur, especially if the bladder is full at the time of injury.

Suggestive signs of intra-peritoneal rupture are severe shock and abdominal dullness and rigidity, together with the non-passage of urine in spite of fluids being taken by the mouth. A small quantity of blood-stained urine may be obtained by catheter (see also Vol. II, page 2887).

(*c*) *Injuries to the rectum* are rare, and no case occurred in the series of 100 quoted. Complete investigations of a case of pelvic injury should, however, include a rectal examination. When the sacrum or coccyx is injured, it may be possible to palpate or replace a fracture by this means.

(*d*) *Injury to the pelvic veins* may result in thrombosis. Occasionally

pulmonary embolism has occurred, and in other cases the thrombosis has extended to the femoral vein, the resulting œdema of the leg proving a serious disability.

(e) *The sacral nerves* emerge through foramina considerably larger than the diameter of the nerve trunks. Hence, pressure from displaced fractures or by callus is rare, but sciatic pain as a sequela of pelvic injury must be borne in mind.

Treatment of Uncomplicated Cases.

The treatment of shock should be the first consideration.

In the majority of cases, displacement is negligible and all that is necessary is to support the pelvis with a firm binder. The patient should be nursed on a divided mattress, and kept in bed for a minimum of six weeks. Instead of a binder, a well-moulded pair of "plaster knickers" may be applied, including the pelvis and both thighs as far as the knee. A plaster bed can be used, extending from the middle of the back to the knees.

If one side of the pelvis is displaced upon the other, the movement is usually in an upward direction, owing to the pull of the abdominal and psoas muscles. Should this happen, an attempt may be made to overcome the deformity by continuous traction upon the leg, after the manner of Hoke's traction for dislocation of the sacro-iliac joint. The patient may be allowed up in his plaster after six weeks, and may attempt to walk with the help of crutches. A period of three months will probably be necessary before the plaster and crutches can be discarded completely.

When fractures of the pelvis are complicated by injury to the urethra, bladder, rectum or other viscera, primary treatment is directed to the visceral complication. A prompt diagnosis of the complication is essential for a satisfactory recovery, and neglect of the fracture of the pelvis until the visceral lesion is dealt with seldom affects the prognosis of the fracture.

The *prognosis* after simple fracture is satisfactory but progress is slow. There is commonly complaint of a feeling of insecurity about the pelvis, particularly when walking.

Treatment of urethral and bladder injury is described in Vol. II, pages 3066 and 2888.

Acetabulum.

(1) Fracture of the rim.

(2) Fracture of the floor (central dislocation of the hip joint).

(1) Fracture of the rim of the acetabulum is usually associated with dislocation of the hip joint. The postero-superior portion of the rim is

separated upwards. It is recognisable by the fact that reduction of the dislocation is easy, but its retention is difficult. There should be no mistake about the diagnosis from the X-ray pictures.

Treatment consists of reduction of the dislocation under an anæsthetic and of fixation of the thigh in a position of full abduction.

In a young patient a plaster spica should be employed, extending from above the waist down to and including the foot on the affected side. Such an appliance is not suitable for an elderly or heavily-built patient, who should be placed on a divided mattress, and strapping extension applied to the limb and to an extension pulley. Some degree of tilting of the pelvis can be prevented by the use of a flannel bandage applied as a pelvic band round the sound groin and tied above to the opposite corner of the bed.

In young patients, if the fractured portion includes a considerable area of the roof of the acetabulum, the fractured portion of bone should be fixed in place by an open operation.

(2) A direct blow applied to the region of the great trochanter may drive the head of the femur into or through the floor of the acetabulum so that the acetabulum becomes comminuted.

Treatment. When the floor is fractured without inward displacement of the head of the femur, the patient should be put to bed and a weight extension applied to the limb for six weeks. Subsequently, a weight-bearing caliper should be worn for another six weeks. Inefficient treatment will be followed by painful ankylosis of the hip. Even after the best treatment, a painful hip with limitation of movement will sometimes occur. In the more severe cases, arthrodesis may be required.

When the femoral head is driven through the floor of the acetabulum, an attempt must be made to disengage it under a general anæsthetic. Fixation is then required in a position of 20 degrees flexion, with slight external rotation and abduction so that, should ankylosis occur, the ultimate function of the limb will be the best possible.

Failure to reduce the head by manipulative traction should be followed by the insertion of a screw into the great trochanter and the application of traction. An open reduction involves an intra-pelvic operation and leaves a condition of the hip which is painful and will be followed by secondary arthritis. These fractures are serious injuries; considerable limitation of movement is to be expected; pain is a frequent sequela and arthritis occurs later.

Note. In viewing skiagrams of elderly patients, the floor of the acetabulum may appear to have sunk into the pelvis, the femoral head appearing deeply placed. The condition may be bilateral and is one of "protrusio acetabuli," not necessarily associated with a past injury.

FEMUR

Upper End of Femur

This region includes the head, neck and trochanters. Various classifications are in use, but the simplest would appear to be that based upon the anatomical site of the fracture. Hence we may speak of capital: sub-capital; cervical; basal; inter- or per-trochanteric; and sub-trochanteric fractures.

The older classification into intra- and extra-capsular fractures has no particular advantage, and leads to much confusion as to the exact type of the fracture. Strictly speaking, intra-capsular fractures should

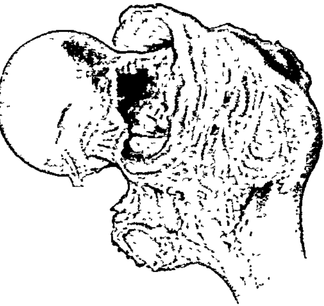

Fig. 2398.—Sub-capital fracture of neck of femur (intra-capsular). (Museum, King's College Hospital.)

include all those occurring above the anterior intertrochanteric line, while extra-capsular should refer to fractures of the intertrochanteric variety.

For purposes of treatment it is sufficient to recognise *three varieties:*

(1) *Sub-capital fracture* (fig. 2398). This is the commonest variety of cervical fracture.

(2) *Basal fracture of the neck* (fig. 2399).

(3) *Inter- or per-trochanteric fracture* (fig. 2400).

(The sub-trochanteric fracture is really a fracture of the upper end of the shaft, and will be considered under the appropriate section, while fracture of the head itself is a rarity.)

The recognition of these three types is of the utmost importance, both from the point of view of treatment and of prognosis. Good

skiagrams are essential and, if possible, a lateral as well as an antero-posterior view should be taken.

Method of taking X-ray pictures of the Neck of the Femur

(*a*) *Ordinary antero-posterior view.* (i) With leg rolled in; (ii) With leg rolled out.

(*b*) *Lateral view.* (i) With legs widely abducted, the film is held parallel with the neck, the edge of the casette being pressed firmly into the soft parts below the costal margins. The X-ray tube is situated in the region of the foot of the sound leg. (ii) The patient is placed in the lithotomy position. The film is held as before, and the tube is located near the perineum of the patient.

The taking of lateral skiagrams in this region will necessitate the use of shock-proof apparatus, and some form of anæsthesia will be necessary to place the limb

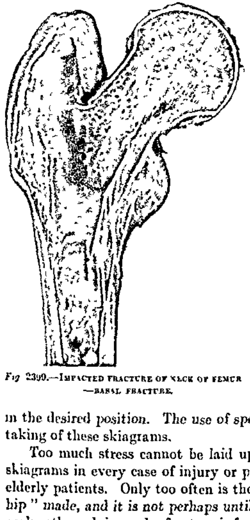

Fig 2399.—Impacted fracture of neck of femur —basal fracture.

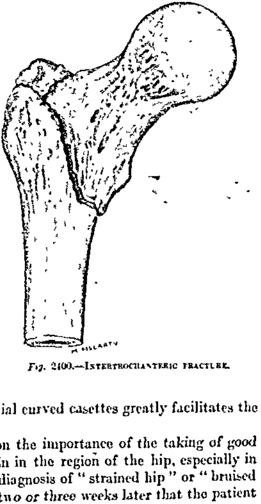

Fig. 2400.—Intertrochanteric fracture.

in the desired position. The use of special curved casettes greatly facilitates the taking of these skiagrams.

Too much stress cannot be laid upon the importance of the taking of good skiagrams in every case of injury or pain in the region of the hip, especially in elderly patients. Only too often is the diagnosis of "strained hip" or "bruised hip" made, and it is not perhaps until two or three weeks later that the patient seeks other advice and a fracture is found.

The type of fracture most likely to be "missed" on clinical examination is the *impacted fracture*, in which there is little or no shortening and no outward rotation of the leg, and on which the patient has possibly walked for some days after the accident.

The possibility of a *pathological fracture*, due to malignant disease, must always be borne in mind; when secondary carcinomatous deposits are the cause, they are usually situated in the sub-trochanteric region rather than in the neck.

General considerations. It should be realised that of the three types mentioned, basal fracture of the neck and intertrochanteric fracture usually unite readily by bone.

Basal fractures are often impacted into the region of the trochanters without much deformity or shortening, whereas in the intertrochanteric variety considerable separation of the fragments, with shortening and coxa vara, is the rule. The treatment of these types is discussed in a later section.

Trans-cervical Fractures

According to recent literature these constitute only one-third of the fractures of the upper end of the femur, the other two-thirds being fractures in the region of the trochanters.

They may be sub-divided into two types:

(1) *Abduction* (Valgus). The angulation of the neck is open upwards and forwards. The fracture is usually impacted. Bony union

Fig. 2401.—Skiagram of fracture of neck of femur, showing coxa vara and rotation of the head.

occurs readily if the fracture is immobilised in a short plaster spica for three months, the patient being allowed to walk after six weeks. The fracture should never be disimpacted.

(2) *Adduction* (Varus). (Fig. 2401.) The angulation of the neck is open backwards and inwards. The head is rotated backwards and the

leg rolled out, so that the fractured surfaces of the neck look forward. Separation of the fragments is the rule, and non-union will occur unless adequate steps are taken to immobilise both the upper and lower fragments in relation to one another.

Reasons for non-union in abduction fractures of the neck of the femur:

(1) The fragments are separated.

(2) The blood supply to the "capital fragment" runs up the neck from vessels supplied by the capsule of the joint. When fracture occurs, both capsule and blood-vessels are torn. In sub-capital fractures the head may become completely avascular.

(3) Even if adequate reduction is obtained by manipulation, movement between the fragments will repeatedly destroy newly-formed vessels, and non-union will result. Torsional or rotatory movements of the head are impossible to control by any form of external splintage.

(4) The usual reasons given for non-union—such as senility, poor blood supply to the neck as a whole, and the presence of synovial fluid—do not appear to carry weight in the light of recent research. Inadequate treatment, i.e. incomplete immobilisation, has been the reason for past failures in this field.

In order to obtain osseous union in this type of fracture the following criteria must be aimed at:

(1) Good alignment and apposition of the head and neck, obtained by manipulative reduction.

(2) Complete fixation of the fragments, relative to one another. This can only be accomplished by operative means.

(3) Relief from weight-bearing for a sufficient time for bony union to take place. Opinions as to the length of this period vary. (Böhler advises rest in bed for 3–4 weeks, followed by walking in a plaster-cast, which is removed in 12 weeks.) When in doubt it is better to err on the side of caution and to check the progress of union by X-ray photographs. In many cases it may be wise to provide the patient with a weight-bearing caliper for several months, even after union appears to be firm on X-ray examination.

Age Incidence and Choice of Treatment.

Whatever form of treatment is adopted, the age of the patient will have an important bearing upon the results. In a survey of 311 cases by Stebbing in 1927, the average age both for cervical and trochanteric fractures was 69 years. These cases were treated by extension or abduction in plaster. In a more recent series of 100 cases by Watson Jones (1936) the average age, excluding the trochanteric region, was found to be 58·5 years.

In deciding what form of treatment to adopt, age, type of fracture, and general condition of the patient must be considered. If the patient with an abducted fracture is unsuitable for operative treatment, then immobilisation in plaster-of-Paris or by some other method may be suitable.

Treatment of Trans-cervical Fractures.

Adduction type. The diagnosis having been made, both by clinical and X-ray observations, the method of choice is undoubtedly that of operative fixation of the fracture by the Smith-Petersen nail. The virtue of the nail lies in the fact that it is provided with three flanges which firmly engage the femoral head and make rotatory movements impossible. Wires, screws, and bone pegs or grafts are all open to the objection that, being rounded, they cannot grip the femoral head. Bone grafts have the additional disadvantage of liability to absorption or fracture before bony union is complete. The best type of nail has a central canal, so that it may be threaded over a guide wire previously inserted.

When to operate is an important point. There is no extreme urgency, and probably the best plan is to put the patient to bed, with a weight extension on the leg, for about a week, and then to perform the operation. During this time, initial swelling will have subsided, and there will be ample opportunity for a detailed investigation of the general health. It should be emphatically stated that, if operative treatment be decided upon, the operation should *not* be undertaken lightly, and then only by one versed in the technique. It is beset with difficulties and not a few dangers.

Two methods of insertion of the nail are in use:

(1) By open operation ; or

(2) By "blind" insertion.

(1) *Open Operation.*

(*a*) The fracture is first reduced by traction ; the femoral neck is then exposed and the accuracy of reduction checked. The guide is inserted under direct vision, and its position subsequently checked by X-ray examination. The nail is then inserted.

(*b*) The femoral neck is exposed and the fracture reduced by traction under direct vision. Guide wire and nail are inserted by direct vision without the help of X-ray photographs.

(2) "*Blind*" *Insertion.*

In this method, the fracture is reduced by traction and the guide inserted through a small incision below the great trochanter. The accuracy of insertion is checked by skiagrams before insertion of the nail.

Accurate insertion is facilitated by the use of: (*a*) Mechanical appliances (Hey Groves, Eric Lloyd, and others); and (*b*) Bony points of the skeleton (Johansson).

Of the two methods, there can be no doubt that insertion of the guide wire by open reduction, with free exposure of the site of the fracture, is the method of choice. This is carried out as follows:

(*a*) The fracture is visualised, and the accuracy of reduction is checked.

(*b*) The guide wire is inserted under direct vision.

(*c*) Elaborate instruments for controlling the insertion of the guide wire are unnecessary.

(*d*) Few arithmetical and no geometrical calculations are required.

(*e*) It is possible to obtain accurate placing of the guide wire (and of the nail) without the use of X-ray examination in the operating theatre, although a skiagram check is an added advantage. If skiagrams are dispensed with during the operation, operating time may be reduced from the necessary 1½–2 hours to within 1 hour. On the other hand, it must be admitted that the operation is one of considerable magnitude, involving extensive dissection, and is open to the usual operative risks.

Shock, however, does not appear to be greatly increased when the "open" method is used, and the time saved more than compensates for the added exposure and loss of blood.

Both methods will now be described in some detail:

(1) *Insertion by Open Operation (Modified Smith-Petersen).*

(*a*) *Anæsthetic.* The blood-pressure should be taken, and if not abnormally low a spinal anæsthetic (percaine) should be given. Conditions will be more satisfactory for patient and operator if sufficient gas and oxygen to produce unconsciousness be administered. Should spinal anæsthesia be contra-indicated, gas-oxygen-ether is probably the best substitute.

(*b*) *Operating table.* Some form provided with a perineal post against which traction can be made is desirable. Screw-traction appliances to the feet are a great advantage, but not essential, as in their absence the foot can be controlled and traction applied by an assistant.

(*c*) *Choice of nail.* Before operating, it is necessary to have an X-ray picture of the *normal* hip of the patient, together with a Smith-Petersen nail, of known length, or a steel measure, on the same film.

FIG. 2102.—HOLLOW SMITH PETERSEN PIN.

It is then easy to decide what length of nail will be required, and errors due to distortion are avoided.

(*d*) *Incisions:* (i) Smith-Petersen (see fig. 2344 B); or (ii) Lateral approach (fig. 2403).

Occasionally the large flap turned down in the Smith-Petersen

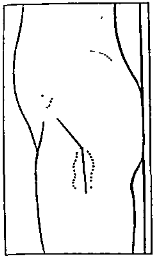

Fig. 2403.—Lateral approach to the neck of the femur.

incision may slough. A lateral approach is advocated to avoid this danger (Watson Jones).

If the Smith-Petersen approach is employed, the rectus femoris and tensor fasciæ femoris are retracted outwards, and the capsule of the joint is divided in a longitudinal direction.

If the *lateral* approach is used, the tensor fasciæ femoris is pulled forwards and the gluteus medius partially detached from its insertion

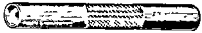

Fig. 2404.—Hollow punch to fit over guide pin for driving nail home.

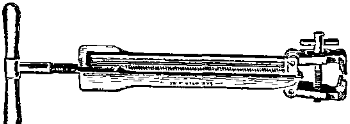

Fig. 2405.—Extractor for removal of Smith Petersen pin.

into the great trochanter and retracted backwards. The capsule is incised along the intertrochanteric line as well as longitudinally, and the triangular opening thus made gives a good view of the neck.

Care should be taken of the exposed muscles by repeated applications of hot cloths.

(*e*) The leg is now rolled out, thus exposing the fractured surfaces. A guide wire is inserted in the centre of the femoral shaft, $\frac{1}{2}$–$\frac{3}{4}$ inch below the base of the great trochanter, and drilled into the bone with an ordinary Kirschner wire drill. (If a rigid pin is used as guide an "awl" handle may be employed.) The guide is made to appear in the centre of the fractured surface of the neck.

(*f*) *Reduction* is now obtained by traction on the leg in the direct line of the body. No abduction should be used at this stage, but slight flexion and internal rotation may help in accurate reduction. Accuracy of reduction is controlled by direct vision, when complete abduction will "lock" the fragments together.

The guide wire is then driven into the proximal fragment for the required distance. (The length of guide necessary may be measured from the X-ray picture of the normal hip, taking into account the distortion which is always present in X-ray films.) It is important that the articular cartilage of the head should not be pierced. At this stage many operators prefer to have the position of the guide wire checked by antero-posterior and lateral skiagrams. If this is done, great care must be taken not to introduce sepsis into the wound. The film casette must be wrapped in sterile towels and the wound itself adequately covered.

Having decided, by visual or radiological control, that the fracture is perfectly reduced and the guide inserted correctly, the nail is now threaded over the guide and hammered home with the special hollow punch. Care must be taken that the guide is not driven into the acetabulum during this process.

The guide is removed and a further film taken. If the position of the nail is unsatisfactory it must be extracted with the special extractor and re-inserted. Accuracy of reduction and firm fixation does away with the necessity of impaction by a hammer.

The wound is closed, and it may be advisable to drain it for twenty-four hours, as the large hæmatoma which sometimes forms is liable to become infected.

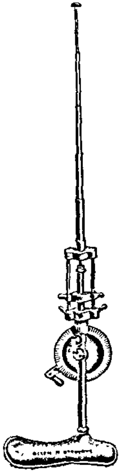

Fig. 2406.—Telescopic introducer for guide wires when used alternatively to rigid guide pin.

It is then easy to decide what length of nail will be required, and errors due to distortion are avoided.

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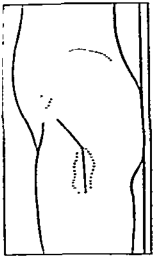
Occasionally the large flap turned down in the Smith-Petersen



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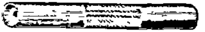

Fig. 2404.—Hollow punch to fit over guide pin for driving nail home.

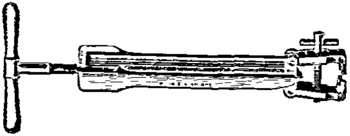

Fig. 2405.—Extractor for removal of Smith-Petersen pin.

into the great trochanter and retracted backwards. The capsule is incised along the intertrochanteric line as well as longitudinally, and the triangular opening thus made gives a good view of the neck.

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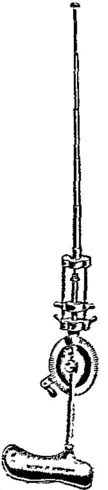

Fig. [illegible]—[illegible]

Fig. 2406.—SKIAGRAM SHOWING FRACTURE OF NECK OF FEMUR WITH GUIDE WIRES INSERTED. NOTE THAT THE LIMB IS TOO MUCH ABDUCTED, BUT THE COXA VARA AND ROTATION HAVE BEEN CORRECTED.

Common Mistakes in the Open Operation (fig. 2407).

(*a*) Incomplete reduction before inserting guide into head.

(*b*) Neglect to take lateral as well as antero-posterior views at each stage of the operation.

(*c*) Guide placed excentrically. The nail then engages with the side of the head and tilts it, so that a firm hold is not obtained.

(*d*) Pin too short; head not held firmly.

(*e*) Pin too long; acetabulum pierced or damage done to pelvic organs.

(*f*) Guide driven in when the nail is hammered home. Use of special hollow punch should prevent this.

(*g*) Sepsis introduced into the wound.

These mistakes can only be avoided by experience and by strict attention to detail at each stage of the operation.

(2) *The "Blind" Operation* (*Sven Johansson*).

The advantages of this method are that no exposure of the femoral neck is necessary and the hip joint is not opened, the guide and nail being inserted through a small incision below the great trochanter.

Possibly there is less shock than by the open method and therefore the scope of the operation may be somewhat increased. On the other hand, the technique is difficult and tedious; X-ray apparatus must be available in the theatre, and the operator must wait while films are being developed. Several sets may be necessary, and the operating

time is thus much increased. If two distinct sets of X-ray apparatus are available, some time can be saved in the taking of the antero-posterior and lateral views.

Technique. The patient is anæsthetised and placed upon an orthopædic table fitted with perineal post and traction apparatus for the feet. Traction is applied with the feet about 12 inches apart and the legs rolled slightly inwards.

The direction of the neck of the femur is estimated in the following manner:

A point 1 cm. below the middle of Poupart's ligament is marked on the skin by a small piece of lead. This marks the highest point of the head of the femur. Another point is marked by lead about 8 cms. below the tip of the trochanter. The line joining these two marks indicates the direction of the femoral neck. Antero-posterior and lateral skiagrams are now taken and the accuracy of reduction and position of the neck, relative to the lead marks, is checked. If correct, a small incision is made at the base of the trochanter and a Kirschner wire drilled into the neck, using the lead marks as a guide. It is best to insert three wires in all, the second and third being above and below the first, but in the same horizontal plane. The length of wire to be inserted must be carefully checked beforehand, by measurement from the normal femur in the manner described under the "open" method.

Another set of X-ray pictures is taken, and the position of the wires observed, in both the antero-posterior and the lateral views. A correctly-placed wire should be exactly in the centre of the neck and head, both in the vertical and in the horizontal planes. (Should none be in a sufficiently good position, the wires must be extracted and re-inserted.)

The wire in the best position is left *in situ* and the others are withdrawn.

A Smith-Petersen nail, of the requisite length, is now threaded over the guide and hammered home with the hollow punch, care being taken not to drive the guide in with it. The guide is withdrawn, traction is released, and the neck is gently impacted into the head with the impactor. The function of impaction is to close the gap between the fragments, and it should not be too vigorously employed. The nail is driven home once more and the small incision sutured.

Finally, a third set of X-ray films is taken to check the position of the fracture and nail. Should either prove to be unsatisfactory, the nail must be withdrawn with the extractor and the whole operation repeated. (Withdrawal of the fully inserted nail is often extremely

difficult, and may result in considerable splintering of the bone of the great trochanter.)

Common Mistakes in the "Blind" Operation are:

(*a*) Neglect to check accurate reduction of the fracture by antero-posterior and lateral X-ray photographs before attempting to insert the guide wires.

(*b*) Attempts to complete reduction of the fracture after the guide is inserted, resulting in bending or breaking of the guide.

(*c*) Placing the nail excentrically. The head is not gripped properly and tilting of the head on the neck will result (fig. 2408).

(*d*) Perforation of the acetabulum by guide or nail. (The pelvis is sometimes entered. This can only be avoided by careful measurements beforehand, and by constant X-ray checks during the operation.) If the nail is found to have perforated the articular cartilage, it must be withdrawn slightly.

After-Treatment. After reduction and fixation by either method, the patient is returned to bed without any form of external splintage. Knee movements should be encouraged from the day after the operation, and gentle hip movements a few days later.

It is difficult to lay down a definite curriculum which will cover every case, and modifications may be introduced if subsequent X-ray examination shows that ossification is well advanced. As a general rule, however, it is wise to keep the patient in bed for 10–12 weeks, during which time active exercises and massage are given daily. At the end of this period, a weight-bearing caliper is fitted, and walking may be started. The caliper should be worn for 3–6 months. It must be admitted that this routine errs on the side of caution, and that many surgeons permit weight-bearing much earlier, with or without the protection of a short plaster spica.

Some Late Complications.

(*a*) Rarefying osteitis around the nail.

(*b*) The nail may become loose and will usually tend to work out but may pass upwards. The head may be felt beneath the skin. In this case, the nail should be removed as soon as the fracture is firmly united.

(*c*) Fracture of the nail, due to too early weight-bearing.

(*d*) Late arthritic changes in the joint.

Treatment of Sub-capital Fractures by Methods other than Operation.

Although operative fixation is the treatment of choice in adduction fractures of the femoral neck, and is also advocated in certain selected cases of basal fracture, there still remain a number of cases in which, owing to age, pre-existing disease, or other reasons, operative treatment cannot be carried out.

Fig. 2408.—Skiagram showing fracture of neck of femur. Imperfect reduction, pin placed rather low. Good bony union was obtained.

Fig. 2409.—Skiagram showing fracture of neck of femur. Reduction fair, pin correctly placed.

Fig. 2410.—Skiagram of lateral view of neck of femur, showing fracture line and pin placed centrally in neck.

For these cases, two methods are applicable:

(1) *Plaster-of-Paris Spica.*

Suitable cases:

(*a*) *Sub-capital Fractures*:

(i) Some cases of adduction fractures unsuitable for operation.

(ii) Abduction fractures.

(*b*) *Basal Fractures.*

(*c*) *Per-trochanteric fractures with no displacement.*

"*Whitman's Abduction Treatment*" *for* (*a*) *and* (*b*).

Until the Smith-Petersen operation became fashionable this was the standard method of dealing with fractures in the region of the hip joint. It is claimed that bony union is obtained in about 66 per cent of cases of all ages.

The method, though usually considered in relation to cervical fractures, is also applicable to basal fractures.

The *principles* are simple: (i) Reduction of deformity by manual traction. (ii) Locking of the fragments by full abduction and internal rotation of the leg. (This is brought about partly by the tension of the anterior part of the capsule, and partly by leverage of the femoral neck against the upper lip of the acetabulum.) (iii) Fixation of the leg in the position of abduction and internal rotation by means of a plaster spica.

Details. The patient is anæsthetised on an orthopædic table. Stockinette is applied smoothly to cover the whole of the injured leg and the body as high as the axillæ, the skin being previously powdered. Each leg is held by an assistant and equal traction is applied, the patellæ being rolled inwards. The surgeon applies pressure over the region of the trochanter. Both legs are then abducted as fully as possible, care being taken that the pelvis is maintained square with the body.

Accuracy of reduction may be checked by measurements, or by X ray examination.

Sheet wadding is applied, paying special attention to the padding of bony prominences, such as the sacrum, trochanter, spinous processes, anterior spines, and malleoli. It is better to use felt over these prominences if the patient is thin. Plaster bandages are used to construct a spica, which must extend from the axilla on the non-affected side, including the pelvis and the whole of the affected limb. The knee is flexed to about 30 degrees.

A well-applied spica should fulfil the following conditions:

(i) Affected limb:	Full abduction. Full extension. Slight internal rotation, maintained by flexion of the knee. Foot at right angles.
(ii) Sound limb:	Free. Full flexion should be permitted.

After-Treatment.

(i) Skiagrams to check position of fragments.

(ii) Prevention of sores by nursing patient part-time on back, then on face, and then on sides.

(iii) Raising *head* of bed to avoid congestion.

Duration. A period of *three* months in the spica will be required for a cervical fracture, and rather less for a basal fracture. Following this, a month in bed, during which time massage and exercises are given, and finally a period of ambulatory treatment for a further two or three months, during which time a weight-bearing caliper is worn.

Difficulties of abduction methods. The construction of a plaster spica which will stand up to the strain and stress of three months' nursing is no mean undertaking. Some 20–30 bandages (6–8 inches wide) are necessary. Sores are apt to develop, in spite of every care. The nursing of such a case is heavy, and lifting will require at least four helpers.

When plaster is employed for a *sub-capital abduction fracture*, a short plaster spica with the leg in " adduction " is made, walking being allowed from an early date.

(2) *Simple Traction.*

The methods of treatment already described are unsuitable for the aged or infirm. Nevertheless, a definite line of treatment should be instituted, although the hope of obtaining a firm union by bone is remote, and the best that can be hoped for is a fibrous ankylosis.

The practice of putting the patient to bed with the legs " between sand-bags " is to be condemned. Fixation of the leg in this way merely ensures that whenever the body is moved, movement inevitably takes place at the fracture line, causing considerable pain and discomfort. These patients should be " put up " on a simple weight extension applied either by adhesive strapping, or, better, by a Kirschner wire inserted through the crest of the tibia. Rotation can be controlled in this way. Counter-extension is made by raising the foot of the bed.

The leg is allowed to lie on a Thomas splint, bent at the knee, or on a Braun frame. The foot must be kept at right angles. A weight of 10–15 lb. will be sufficient. The weight extension is continued for about

three weeks, but a skiagram should be taken after a few days, to check the correctness of the weight. Should this be too small, coxa vara will persist, or if too large, coxa valga may result. The patient is then provided with a walking caliper and allowed to get about, at first with crutches, and later with the aid of sticks. The caliper will probably need to be worn permanently.

Basal Fracture

This type of fracture is usually impacted, and therefore little displacement is the rule. Bony union is to be expected.

Two methods of treatment may be adopted : (1) Fixation in a plaster-cast, on the lines of the Whitman method already described ; or (2) Treatment on a Thomas or Braun splint by moderate traction, even if the fracture is impacted. Recumbency for about twelve weeks will be required and a walking caliper is advisable for six months afterwards.

Per-trochanteric Fracture

This type is often accompanied by shortening and coxa vara. The lesser trochanter may be separated from the shaft. The mechanism, according to statistics of 207 cases (Stebbing), is that the body weight is suddenly thrown on to the femur when the leg is in *adduction.* Direct blows on the trochanter are rarely causative. This view is contrary to the usual teaching and is not supported by experiments upon the cadaver.

The *treatment* consists of continuous weight extension for a period of 12–14 weeks. Maintenance of internal rotation and abduction are of importance and a walking caliper should be used subsequently.

(Details of weight extension and the prevention of stiffness of the knee are considered under Fractures of the Shaft of the Femur. See page 4481.)

Treatment of Non-union in Fractures of the Femoral Head

Given a case of un-united fracture of the neck of the femur, the question arises, Should anything be done, and if so, what ?

The answer to the first part of the question can only be found by study of the individual case. Age, condition, amount of disability, and presence of pain must all be considered. X-ray pictures must be taken to determine the degree of deformity and the condition of the femoral head. If the bone density of the head is similar to that of the shaft, it may be assumed that the head is still living. If the head is dense, it is probably avascular and dead. In the presence of an avascular

or an absorbed "head," operative fixation of the fracture by nailing is obviously useless, and consideration may be given to some form of reconstructive procedure.

Successful reduction and fixation of an un-united fracture has been seen by the author in a middle-aged man, a year after the original injury.

The following *methods of treatment* are available:

(1) *Fixation of the Fracture* (femoral head alive).

(*a*) Skeletal traction in an endeavour to overcome coxa vara.

If successful, (*b*) Fixation of fracture by Smith-Petersen nail.

(i) Open operation in order to freshen bone-ends.

(ii) By "blind" method.

(*c*) Fixation by bone graft.

(2) *Osteotomy* (Sub-trochanteric).

(*a*) *Simple*—in order to restore the normal relationship between the shaft and neck of the bone.

(*b*) *Bifurcation operation.* An oblique osteotomy is made through a 5-inch incision over and below the great trochanter. The shaft is displaced inwards so that it lies partly under the head and partly under the lower border of the acetabulum. This is controlled by direct vision. Fixation is effected by a plaster spica for 3–4 months. Bony union should occur between the shaft, head and trochanteric region.

The latter is the method of choice, as in a simple osteotomy the fibrous union at the site of fracture persists.

(3) *Reconstruction operation* (e.g. Whitman's).

(4) *Arthrodesis of the hip joint.* (This is difficult and liable to failure.)

Separation of the Upper Epiphysis of the Femur

Fractures in the region of the femoral neck are uncommon in children and adolescents, but when they occur the epiphysial line is often involved. Treatment should be on conservative lines either by continuous traction or by reduction and fixation in a plaster spica.

Of different ætiology is the "so-called" "slipped epiphysis" of the upper end of the femur.

The condition occurs in adolescents between the ages of 10–15, i.e. before union of the epiphysis with the neck, which occurs about the 18–20th year. The patient is often of the fat, heavy type, with under-developed genitalia, suggestive of pituitary insufficiency. Enlargement of the sella turcica, as seen in a lateral X-ray picture of the skull, has been recorded.

The history is usually one of slight injury, such as a fall or twist of the leg whilst running. The child may get up and continue to walk or limp about subsequently. In some cases the condition is not discovered for some days, until there is pain, or a limp is noticed by the parents. On examination, there is adduction and external rotation of the affected limb, raising of the trochanter, and shortening of ¼-inch to ¼-inch. Movements are full except for abduction and internal rotation, which may be greatly limited. A skiagram is essential for accurate diagnosis. The lower lip of the epiphysis will be seen projecting below the lower border of the neck, the deformity being similar to that of an (adduction) sub-capital fracture in an adult. A notable feature is the absence of any bony spicule broken from the diaphysis, which is constantly present in slipped epiphyses in other situations (e.g. lower end of radius).

Should the case be of long standing, the displaced epiphysis will have fused with the femoral neck, the result being one form of *adolescent coxa vara*.

Treatment. This may be considered under three headings:

(1) *Within three or four weeks of the injury*.

(*a*) Reduction of the deformity under anæsthesia by manual traction, followed by abduction and fixation in a plaster spica; or

(*b*) Reduction by continuous traction, exerted over a period of three months, until union is firm. The traction is combined with a gradual increase in abduction and internal rotation.

As the epiphysis is firmly engaged with the femoral neck, forcible traction may do no more than rotate the epiphysis in the acetabulum.

The method of reduction by continuous and gradual traction is much to be preferred.

When complete it may be continued until union is firm, or fixation may be effected by a plaster spica.

(2) *After four weeks* reduction will probably be impossible except by open operation, and fixation of the epiphysis by means of a bone peg or graft.

After-Treatment. Relief from weight-bearing by means of a caliper should be insisted upon for from 3–6 months after the initial period.

(3) *Late cases*, where union has occurred. Sub-trochanteric osteotomy should be performed in order to correct the coxa vara. Some shortening will be permanent. Limitation of movement at the hip joint is usual.

Prognosis. In *early* cases, when reduction and fixation has been satisfactory, the femoral head and neck may be expected to shape

normally. When reduction has been moderate, good function is to be expected for some years, but osteo-arthritis will develop subsequently. Open reduction is usually followed by a completely or partially ankylosed joint.

When reduction has been carried out by forcible manipulation and in some cases of non-reduction, the head will undergo the changes associated with deficient blood supply, and a stiff joint and early fusion of the head and neck will occur.

When reduction is imperfect, the epiphysis will often fuse with the shaft during the first year after the accident.

In *unreduced cases*, coxa vara will develop, and in later life osteo-arthritis is inevitable.

Early fusion of the epiphysis will result in shortening of the limb.

Shaft of the Femur

This group includes:

(1) Sub-trochanteric fractures.

(2) Fractures of the shaft proper.

The majority of cases occur in young adults and children. The type of fracture in adults may be either transverse or oblique, a common variation being the "butterfly" fracture, in which a triangular loose fragment becomes detached from the shaft. In children it is nearly always a long oblique or spiral fracture. Owing to the thick covering of muscles with which the bone is provided, open fracture is rare, but when it does occur, the consequences are likely to be serious owing to difficulty in maintaining accurate alignment during the longer period of union, which may result from: (*a*) Infection of the large hæmatoma and lacerated muscles; (*b*) osteo-myelitis and necrosis of bone; (*c*) delay in union, or non-union; or (*d*) stiffness of knee and ankle.

These fractures are usually accompanied by considerable shock.

Fracture of the Upper Third

The upper fragment is flexed by the ilio-psoas, and abducted and externally rotated by the gluteus medius, obturator internus and allied muscles. Control of the upper fragment is not possible, except by open operation, and it is necessary to remember that alignment must be obtained by bringing the lower fragment into a corresponding position.

Fracture of the Middle and Lower Thirds

Here, apart from the common factor of shortening or overlap, the adductor group is of importance ' lly the adductor magnus).

The upper fragment tends to lie on the inner side of the lower fragment and often at an angle with it, the angle being open outwards (i.e. valgus).

Gravity is of considerable importance. Backward angulation of the fracture due to this cause is of frequent occurrence, both in the early and in the later stages of treatment.

Diagnosis is usually easy. The severe pain and shock, marked swelling, mobility, shortening and external rotation of the foot cannot be missed. The only cases likely to present difficulty in diagnosis are those of partial fractures in children, with a minimum of deformity, and these are rare.

X-ray examination *before* reduction of the fracture is desirable, but not always necessary, and may be omitted if not readily accessible. It should *never* be omitted *after* reduction, and in the majority of cases a portable apparatus is essential, because the patient and extension appliances cannot be moved into the X-ray room.

Treatment.

First Aid. Shock should be prevented as far as possible by keeping the patient warm. Ambulance attendants and others should be instructed that on no account must the patient be moved or lifted until a splint, possibly improvised, has been applied. The temporary splint of choice is a Thomas' provided with a large ring which can be slipped over the clothing. Fixed extension is easy to obtain by means of a clove-hitch over the boot, or a skewer thrust between the sole of the patient's foot and that of the boot. The extension is tied firmly to the end of the splint, the ring making counter-extension on the tuber ischii. The use of a Liston splint, so often applied as a first-aid measure, is bad. It is "better than nothing," but does not allow the application of extension which is so essential in the transport of these cases. The Thomas splint is easier to apply and far more effective. On arrival at hospital, the patient's general condition must be noted and treatment of shock, if necessary, should be carried out before the first-aid fixation is removed. A blanket bath or other exposure is to be avoided, as it is essential to keep the patient warm.

Reduction. Accurate reduction of a fractured femur can only be carried out by *traction*, which may be either:

(1) *Rapid.* (*a*) Manual; (*b*) Mechanical (screw-traction apparatus).

(2) *Continuously applied by means of a weight* through: (*a*) Adhesive strapping; (*b*) Skeletal traction appliances.

Manual traction is only applicable to children or adults with poor muscular development. When the method is to be used, it is best to apply the means of fixation of the fracture (i.e. adhesive strap-

ping) to the leg *before* traction is made. It is difficult otherwise to maintain traction and apply the strapping at the same time. When the traction has overcome all overlap, as checked by an assistant with a tape measure, a well-fitting Thomas splint is slipped on and the adhesive plaster tied firmly to the end of the splint. This method of *fixed extension* will maintain the degree of reduction already obtained, but in the event of incomplete reduction, no improvement in position will take place.

Should reduction be found to be incomplete, either by measurement or X-ray examination, some other method must be adopted.

Fixed extension is more suitable for children over the age of four, in whom it is usually easy to obtain complete reduction at the first attempt.

Screw traction should *not* be used for treatment of fractures of the femur, as a general rule. Its chief application is to the tibia, but in certain cases which are to be treated in plaster-of-Paris, the use of screw traction may be indicated.

Adhesive strapping: The chief applications for this method are in: (i) Children; (ii) Poorly-developed adults; and (iii) The later stages of treatment after the removal of skeletal traction.

Its usefulness is limited by: (i) The breaking strain of the material; (ii) Its adhesive power to the skin; and (iii) The amount of pull that may be applied to the skin without the development of sores.

In general, it may be said that 10 lb. is the limit of weight which can be used in conjunction with strapping, and as this weight is *insufficient* to reduce overlap of a fractured femur in a well-developed adult, the method of traction by adhesive strapping is a limited one.

The best type of strapping is *elastoband*—extension bandage (Smith and Nephew). This material is not expansile in the length of the strapping, but will stretch in width and therefore fits the limb.

Skeletal traction. The advantages, method, and sites of application have been considered in a previous section (see page 4395).

The Steinmann pin is recommended. If traction is to be made from the lower end of the femur, the pin should be used in preference to the wire as it is difficult to control the direction of a wire, owing to "whip" in the portion passing through soft tissue.

Site for traction (see fig. 2371).

The upper end of the tibia is usually advised, because it is:

(i) Accessible; (ii) Remote from the knee joint; and (iii) Remote from the hæmatoma surrounding the fracture.

Common sense must be used in the choice of site, but a pin inserted

through the lower end of the femoral shaft has the following obvious advantages: (i) A direct and better control of the lower fragment of femur is obtained. More powerful traction is possible. (ii) The traction is not applied through the ligaments of the knee joint, so that the risk of an *unstable* knee is avoided. (iii) The knee is left free for movement from the first. In spite of assertions to the contrary, the knee joint is *not* easily moved when the pin is placed in the tibia. (iv) Damage to the knee joint is inexcusable. It may be avoided by placing the pin in the lower third of the shaft and *not* immediately above the condyles. (v) Damage to the femoral artery is unlikely to occur if ordinary care is taken.

Direct contra-indications are: (i) Fracture in lower third (pin through site of hæmatoma); and (ii) Local sepsis or potential sepsis (i.e. an open fracture).

Anæsthesia. Deep general anæsthesia is required during the stages of insertion of the pin, manual traction, and adjustment of the splint. It is of great advantage to apply manual traction even if skeletal traction is to be used subsequently, as a large amount of overlap may be reduced when the muscles are completely relaxed. In Continental clinics, local anæsthesia is the routine method. but it seems better to reserve it for special cases in which the administration of a general anæsthetic is inadvisable.

Treatment of Fractures of the Femoral Shaft at different Ages

(1) *Birth injuries* to the femur are unusual, but may result from traction applied to the groin or leg during a breech delivery. The best method of fixation is to flex the thigh acutely on the abdomen and to maintain contact by means of a few turns of flannel bandage. Added support may be obtained, if required, by a moulded splint of metal or plaster, applied to the flexor aspect of the thigh and bandaged into position against the abdominal wall. Traction is not required. Fixation must be maintained until firm union is found upon clinical examination, usually a matter of 3–4 weeks. This method enables the baby to be suckled and his excreta to be attended to with little difficulty.

(2) *Children under five years of age.* The fracture is almost always oblique. The best method of traction is that of Bryant. Adhesive strapping is applied to both legs from groin to ankle. The child is treated on his back, with the lower limbs flexed to a right angle with the trunk. A Balkan beam or other bed frame is fitted to the cot and a cord from the injured leg passed over a pulley on the beam; sufficient weight is attached so that the child's buttocks are just clear of the mattress. The weight of the child's body acting through the site of

fracture is sufficient to bring about reduction. For the purposes of nursing it is convenient to tie the other leg loosely to the beam. Provided the knee of the sound leg can be flexed slightly, no interference with traction will result. The addition of back splints and foot-pieces to the fractured limbs helps the stability of the apparatus.

After four weeks, union will usually be firm enough to dispense with traction. The child should be kept in bed for another four weeks before weight-bearing is allowed, and it is usually advisable to apply a light plaster-cast during this period, for the sake of protection to the soft callus.

(3) *Children over five years of age.* These cases are best treated by "*fixed extension*" applied by means of adhesive strapping and using a Thomas splint of suitable size. The strapping should be applied down each side of the leg, extending from groin to ankle. No provision need be made for knee movements, as full movement will always be obtained at this age, provided accurate alignment has been secured. All overlap can be overcome by manual traction at the time of application of the splint, but should any persist, it is easy to tie a cord to the end of the splint and to apply a weight of 5 to 10 lb. This method of *combined* fixed extension and weight extension is perfectly rational. The "fixed" portion prevents any recurrence of overlap and the weight is used to overcome any that is not already reduced. All that is necessary is to take up any "slack" in the strapping (i.e. see that the ring of the splint is against the tuber ischii) by *daily* adjustments.

An added advantage is that the application of a small weight relieves the pressure of the splint ring against the skin of the buttock and so prevents chafing.

Note. With all extension apparatus a daily inspection is required. Spirit and powder should be "worked in" within the ring and at all pressure points, and care taken to see that the bandage slings on the splint are at the correct tension to prevent angulation. Special attention to the regions of the tuber ischii over the tendo Achillis and heel is advisable.

In from five to six weeks the splint may be removed or, alternatively, after three weeks, when the union is moderately firm, the leg may be put into a plaster-cast, including the pelvis and the foot.

In nearly every case this simple procedure can be carried out *without* an anæsthetic. The method is convenient as the child, once in plaster, can be sent home.

Weight-bearing should not be allowed for eight or nine weeks as a minimum.

(4) *Adolescents and adults.* In the majority of these cases, *skeletal traction* should be used as a routine (see fig. 2411). Counter-traction is

made by raising the foot of the bed 12 to 18 inches. A muscular patient will require a weight of 15 to 20 lb. at the outset, and during the first week X-ray checks should be taken on alternate days. The weight can be adjusted according to the X-ray findings. *Over-extension* must be avoided. At the end of a week, all overlap should be overcome and the

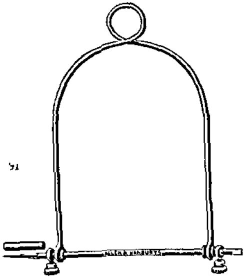

Fig. 2411.—Simple traction pin and stirrup. Note fixation screws to prevent the pin from sliding sideways. The stirrup is free to rotate on the pin, so that the pin does not rotate in the bone.

optimum weight for maintenance of the fracture in good position should have been found.

The most useful splint is the Thomas. It should be provided with a hinged knee-piece, as shown in the illustration (fig. 2412). An adhesive strapping extension should be applied to the lower leg, and a small weight (5 lb.) added in the manner shown in the illustration. In either case, the knee should be slightly flexed so that the leg and foot are clear of the extension cord, which is in the line of the femoral shaft.

Having applied traction, the next step is to adjust the slings so that the normal forward bow of the femur is restored. The slings should be fastened with large safety-pins; the " paper clips " so often used are liable to slip gradually, thus allowing angulation to recur. The thigh and leg may be covered with flannel for warmth, and a " tea cosy " forms a suitable covering for the foot. All coverings must be readily removable for daily inspection.

Finally, provision must be made against *foot drop*. The best method is to attach a cord to the sole of the foot by a strip of adhesive plaster, and to pass the cord over a pulley. A small weight (1 lb.) pulls the foot up to a right angle and at the same time allows the patient to exercise the ankle.

Counterpoise. If a Thomas splint is used, the splint and leg

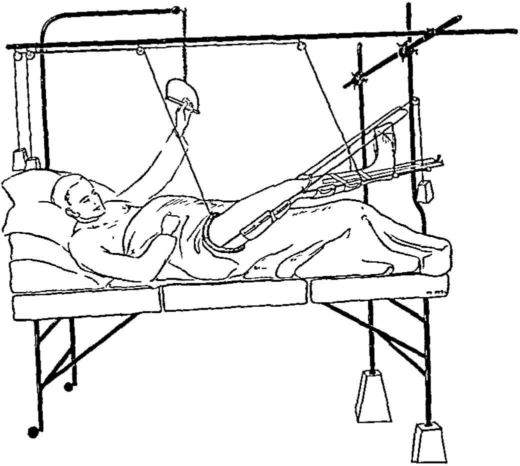

Fig. 2412.—THIS DIAGRAM ILLUSTRATES METHOD OF APPLYING TRACTION FOR FRACTURED SHAFT OF FEMUR ON A FRACTURE BED.

Note traction pin in crest of tibia, weights to counterbalance splint and limb, hinged knee piece of Thomas splint, and support to keep foot at right angle. Foot of bed raised on blocks. Divided mattress is employed.

should be slung *clear of the bed* by means of a system of counterpoise weights. Two cords and weights are needed. One passes from the splint ring over pulleys to the head of the bed. About 5 lb. weight should be attached. This is enough to counterbalance the upper end of the splint when the patient is lifted for the purposes of nursing. The other cord is attached to the lower end of the splint and will need more weight (10 lb.) to balance the weight of splint and leg, so that it is kept clear of the bed. On no account should the splint be tied directly to the bed-rail.

Knee movements. Lateral movement of the patella is carried out from the commencement.

After four weeks, if union is progressing well, *passive knee movements* may be started. A "string and pulley" arrangement which enables the patient to do this himself is valuable.

Faradic stimulation of the *quadriceps* is a valuable adjunct until the

patient can learn to contract the muscle actively. This should be done for ten-minute periods, several times a day. The services of a masseur are necessary at this stage. The progress of union and position should be checked each fortnight by X-ray examination.

Removal of pin or wire. In the majority of cases, it is quite safe to leave the pin *in situ* for 6–8 weeks. If inspection of the site of the pin shows clean wounds, there is no reason why the pin should not remain in the limb longer. When the skin is removed, skeletal traction should be replaced by an adhesive strapping extension. Two sets should be applied, one set exerting traction in the line of the femur, the other in the line of the tibia—this may be applied when the primary setting is done—being fixed to the movable portion of the splint, and thus allowing knee movements to be continued. The strapping extension should be applied *before* skeletal traction is removed. Should suppuration appear at the site of the pin, it must be removed forthwith.

Usually at the end of 10-12 weeks traction may be relaxed and the splint removed. Some delay in union is common and the decision to remove apparatus must be made upon clinical and X-ray findings.

After-Treatment. Faradism and active exercises designed to strengthen the muscles and to increase the range of knee-flexion must be continued. A weight-bearing caliper must always be provided, and no weight-bearing should be allowed for at least another six months

Difficulties in treatment.

(1) The surgeon is often asked to see " late " cases, which have been inadequately treated during the " all important " first week. Prolonged skeletal traction or open operation may be required to obtain a satisfactory result.

(2) Correction of *lateral displacement* is sometimes difficult. The use of sorbo-rubber pads, attached to a small clamp and screw which can be fixed to the bar of the Thomas splint, will usually overcome this difficulty. Lateral pressure can be applied by this means at the appropriate site. Lateral displacement seldom leads to such disability as follows unreduced antero-posterior displacement.

(3) Angulation is easy to correct by pads or by adjustment of the slings when there is no overlap.

(4) In cases of *delayed union*, the temptation to relax traction must be resisted. Traction *must be* continued until union is firm.

Delayed union may be brought about by excessive ardour on the part of the masseur or patient, or by over-extension. If sufficient rest and time be given, union will usually occur.

Late Complications.

(1) *Shortening* of more than ½-inch should be regarded as a bad result.

(2) *Stiff Knee*, due to:

(*a*) Prolonged fixation; or (*b*) Excessive callus formation in fractures of the lower third of the shaft. The quadriceps become adherent to the bone. Excessive callus means union in a bad position, and the complication will not occur in a well-aligned fracture.

(3) *Angulation.* This is due to inefficient treatment or to weight-bearing before the callus is consolidated. A badly-fitted caliper will allow it to occur.

(4) *Arthritis in knee and hip* may occur as a result of *malunion;* abnormal and excessive strain is thrown upon these joints.

Indications for Operations.

(1) *Early.* It is difficult to make out a good case for early operation in fractures of the femoral shaft, in view of the excellent results obtainable by skeletal traction. The risks of sepsis, delayed union due to internal fixation by foreign bodies, and the technical difficulties, are great.

Provided asepsis can be assured, however, operative fixation should still have a place for those cases in which skeletal traction has failed to obtain good alignment after ten days. Exposure of the shaft is made through an antero-lateral incision between the vastus externus and rectus muscles. Only the crureus need be incised. Plating is the best method of fixation, and a stout plate provided with eight screw holes should be used.

(2) *Late.* Cases of non-union or malunion may require open operation. Bone-grafting with or without additional fixation will probably be needed.

Treatment in Plaster-Cast.

Apart from children, the method has a very limited application owing to the impossibility of maintaining traction and to the prolonged fixation of joints which is inevitable. The method should be used for adults only in those few cases which are uncontrollable by other means. Mental derangement, lunacy, or when prolonged recumbency is undesirable, may be cited as examples. The cast must be applied while the femur is under traction on an orthopædic table, and should include the pelvis and the whole of the injured leg.

Supracondylar Fracture

It is important to realise that the lower fragment will be tilted *backwards* by the pull of the gastrocnemius. The sharp upper end of it may damage the popliteal vessels or nerves. *Genu recurvatum* will result if the deformity is not corrected.

so that the fractured surface of the epiphysis looks backwards (*fig.* 2413).

Treatment. This should be immediate manipulative replacement under general anæsthesia. Fixation may be in a plaster-cast with the knee flexed 20 degrees or, alternatively, the limb may be placed on a Thomas splint with extension. Should manipulation fail, skeletal traction must be made from the tibia. Knee movements may be started in four weeks, and a caliper should be worn subsequently.

PATELLA

The bone is fractured in two ways:

(1) *By muscular violence.* (Common in middle age.) The fracture is always transverse, about the middle of the bone, but may be nearer the upper or lower pole. It may be a crack, but commonly there is wide separation of the fragments, due to the action of the quadriceps muscles. It is important to realise that the line of fracture invariably extends sideways into the lateral patellar ligaments, which are part

Fig 2414.—(*a*) ILLUSTRATES SEPARATION OF PATELLA FRAGMENTS WITH IN TURNING OF THE APONEUROSIS. (*b*) FIBROUS UNION JOINS THE FRAGMENTS IN AN UNTREATED CASE.

of the extensor mechanism of the knee. The aponeurosis covering the bone is also torn, and the frayed edges curl in between the bone fragment (fig. 2414*a*), thus preventing bony apposition except by open operation. Fibrous union is certain to occur if the fragments are *separated (fig. 2414b). The result is an unstable knee joint.*

Rupture of the quadriceps tendon may take place instead of fracture of the patella (see also Vol. II, page 3462).

(2) *By direct violence.* This type occurs as a result of a direct blow on the patella. The fracture is stellate, and a minimum of displacement of the fragments is the rule.

Diagnosis. (1) Transverse type.

(*a*) History of having tripped, this being followed by pain. The patient attributes the accident to his subsequent fall. (*b*) Inability to extend the knee joint. (*c*) Great effusion into the joint. (*d*) A gap may be felt between the fragments; this may be masked later by blood clot and effusion. (*e*) X-ray examination.

(2) Stellate type.

The diagnosis is made upon the history of a direct blow, together

Treatment is by skeletal traction, and the knee must be well *flexed*. A Thomas splint is used, bent at the site of the fracture. A pad behind the site of fracture may help to push the lower fragment into alignment.

Fracture of the Condyles

One condyle may be fractured from the shaft when the knee joint is forced into a varus or valgus position. Tear of the opposite lateral ligament may occur.

Both condyles may be fractured in falls upon the foot from a height. The upper end of the tibia is driven between the condyles like a wedge. The line of fracture is into the knee joint, and much effusion of blood into the joint will be present.

Treatment. (1) Manipulation may be tried. It should consist of traction on the leg by an assistant, while the surgeon exerts pressure on the condyles with his hands. If successful, the joint is fixed in a plaster-cast, extending from buttock to foot. The knee should be straight.

(2) More often, open operation will be required. A long lateral incision is made and the joint emptied of blood. The fragments are manipulated into position with bone levers, and fixed by bolts, screws or plates. Gentle knee movements may be started in 3–4 weeks.

In either case after 6-8 weeks a weight-bearing caliper should be worn.

Separated Epiphysis

Separation of the lower femoral epiphysis is an uncommon injury, but may occur before the epiphysis joins the shaft at about the twentieth year. The injury is one of hyperextension of the knee joint

Fig. 2413.—Skiagram showing slipped epiphysis at lower end of femur. In this case a perfect reduction was obtained by manual traction.

so that the fractured surface of the epiphysis looks backwards (fig. 2413).

Treatment. This should be immediate manipulative replacement under general anæsthesia. Fixation may be in a plaster-cast with the knee flexed 20 degrees or, alternatively, the limb may be placed on a Thomas splint with extension. Should manipulation fail, skeletal traction must be made from the tibia. Knee movements may be started in four weeks, and a caliper should be worn subsequently.

PATELLA

The bone is fractured in two ways:

(1) *By muscular violence.* (Common in middle age.) The fracture is always transverse, about the middle of the bone, but may be nearer the upper or lower pole. It may be a crack, but commonly there is wide separation of the fragments, due to the action of the quadriceps muscles. It is important to realise that the line of fracture invariably extends sideways into the lateral patellar ligaments, which are part

Fig 2414.—(a) Illustrates separation of patella fragments with in-turning of the aponeurosis. (b) Fibrous union joins the fragments in an untreated case.

of the extensor mechanism of the knee. The aponeurosis covering the bone is also torn, and the frayed edges curl in between the bone fragment (fig. 2414*a*), thus preventing bony apposition except by open operation. Fibrous union is certain to occur if the fragments are separated (fig. 2414*b*). The result is an unstable knee joint.

Rupture of the quadriceps tendon may take place instead of fracture of the patella (see also Vol. II, page 3462).

(2) *By direct violence.* This type occurs as a result of a direct blow on the patella. The fracture is stellate, and a minimum of displacement of the fragments is the rule.

Diagnosis. (1) Transverse type.

(*a*) History of having tripped, this being followed by pain. The patient attributes the accident to his subsequent fall. (*b*) Inability to extend the knee joint. (*c*) Great effusion into the joint. (*d*) A gap may be felt between the fragments; this may be masked later by blood clot and effusion. (*e*) X-ray examination.

(2) Stellate type.

The diagnosis is made upon the history of a direct blow, together

with local tenderness and effusion. In the skiagram a *bipartite patella* must not be confused with a stellate fracture.

Treatment.

(1) *Transverse or stellate types, without displacement.* A firm pressure-bandage is applied. The joint is immobilised in full extension on a posterior splint. It is best to mould a plaster slab to the limb, from the buttock to the ankle, but a wooden " Ham splint " forms a useful first-aid method of fixation. The limb is elevated upon a pillow. When swelling and pain have subsided, the patient may walk; after three weeks the splint may be removed daily for active exercises to the knee, but no walking should be attempted without it under six weeks.

(2) *Transverse type with separation of fragments.* The limb is elevated and a pressure-bandage and posterior splint are applied. The skin is carefully prepared for operation, which is usually undertaken four days after the injury.

The patella is exposed by a horse-shoe incision, convexity upwards; the incision should extend well laterally, so that adequate exposure of the lateral patellar ligament is made. The fragments are cleared of blood clot and aponeurosis, and excess blood is gently squeezed out of the joint. The methods of fixation of the fragments available are:

(*a*) A number of catgut stitches are passed through the aponeurosis covering the two fragments of bone and are pulled tight to approximate the fragments. The tear in the lateral part of the capsule is closed by catgut sutures. No suture passes through the bone.

(*b*) Each fragment is drilled vertically or horizontally and a

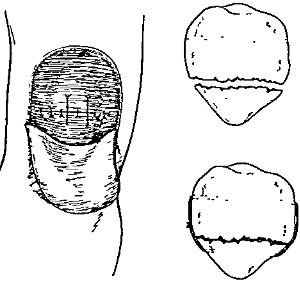

Fig 2415.—Upper figure shows transverse fracture of patella with line of drill holes when placed horizontally. In lower figure fixation material has been passed and fragments drawn together tightly. Left hand figure depicts suture of aponeurosis and lateral portion of capsule. This may be employed alone, and is always the final stage of the fixation.

"mattress" suture of stout catgut or kangaroo tendon is passed through the holes. When tightened, the fractured surfaces should be in close apposition.

(c) A stitch is passed deep to the aponeurosis, and made to encircle the patella, like a purse-string.

In each case care must be taken that the articular surfaces are in accurate alignment. Careful suture of the layers of aponeurosis on either side and in front of the patella is next made, and the skin incision is then closed.

The first type of suture is suitable when the bone fits together easily and the aponeurosis is thick and takes the stitch well. The second type should be considered as the routine treatment. The stitch round the patella can be employed as an adjunct to either of the above methods or may be used alone. As a rule, it does not hold the transverse fracture well if employed alone.

(3) *Stellate fracture with spread of the fragments.* The operation employed is exposure of the patella, clearance of ragged tags of aponeurosis and encircling of the patella with a purse-string suture of thick catgut.

After-Treatment. A firm bandage and a posterior splint are applied over the dressings and the limb is elevated. The stitches are removed on the tenth day. The splint should be worn for six to eight weeks, and walking may be commenced after three weeks. Faradism to the quadriceps muscles is possible without removing the posterior splint. Active knee-joint movements are started in six weeks.

Complications.

(1) If silver wire is used as a suture material, sepsis and bone atrophy may necessitate its removal.

(2) Re-fracture is not uncommon. The other patella sometimes fractures during the period of convalescence.

(3) Some arthritis and stiffness of the knee is likely, as most of the patients with this fracture are middle-aged.

TIBIA

Fractures of the upper end of the tibia extending into the knee joint are of:

(1) The tibial spine.

(2) The condyles of the tibia.

The Tibial Spine

It is important to be aware of the existence of this injury, and to realise that the diagnosis is not difficult and that a definite line of treatment should be adopted immediately.

with local tenderness and effusion. In the skiagram a *bipartite patella* must not be confused with a stellate fracture.

Treatment.

(1) *Transverse or stellate types, without displacement.* A firm pressure-bandage is applied. The joint is immobilised in full extension on a posterior splint. It is best to mould a plaster slab to the limb, from the buttock to the ankle, but a wooden "Ham splint" forms a useful first-aid method of fixation. The limb is elevated upon a pillow. When swelling and pain have subsided, the patient may walk; after three weeks the splint may be removed daily for active exercises to the knee, but no walking should be attempted without it under six weeks.

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(*b*) Each fragment is drilled vertically or horizontally and a

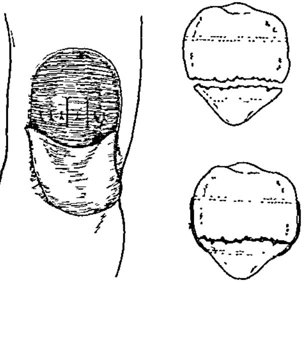

Fig. 2415.—UPPER FIGURE SHOWS TRANSVERSE FRACTURE OF PATELLA WITH LINE OF DRILL HOLES WHEN PLACED HORIZONTALLY. IN LOWER FIGURE FIXATION MATERIAL HAS BEEN PASSED AND FRAGMENTS DRAWN TOGETHER TIGHTLY. LEFT HAND FIGURE DEPICTS SUTURE OF APONEUROSIS AND LATERAL PORTION OF CAPSULE. THIS MAY BE EMPLOYED ALONE, AND IS ALWAYS THE FINAL STAGE OF THE FIXATION.

"mattress" suture of stout catgut or kangaroo tendon is passed through the holes. When tightened, the fractured surfaces should be in close apposition.

(c) A stitch is passed deep to the aponeurosis, and made to encircle the patella, like a purse-string.

In each case care must be taken that the articular surfaces are in accurate alignment. Careful suture of the layers of aponeurosis on either side and in front of the patella is next made, and the skin incision is then closed.

The first type of suture is suitable when the bone fits together easily and the aponeurosis is thick and takes the stitch well. The second type should be considered as the routine treatment. The stitch round the patella can be employed as an adjunct to either of the above methods or may be used alone. As a rule, it does not hold the transverse fracture well if employed alone.

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After-Treatment. A firm bandage and a posterior splint are applied over the dressings and the limb is elevated. The stitches are removed on the tenth day. The splint should be worn for six to eight weeks, and walking may be commenced after three weeks. Faradism to the quadriceps muscles is possible without removing the posterior splint. Active knee-joint movements are started in six weeks.

Complications.

(1) If silver wire is used as a suture material, sepsis and bone atrophy may necessitate its removal.

(2) Re-fracture is not uncommon. The other patella sometimes fractures during the period of convalescence.

(3) Some arthritis and stiffness of the knee is likely, as most of the patients with this fracture are middle-aged.

TIBIA

Fractures of the upper end of the tibia extending into the knee joint are of:

(1) The tibial spine.

(2) The condyles of the tibia.

The Tibial Spine

It is important to be aware of the existence of this injury, and to realise that the diagnosis is not difficult and that a definite line of treatment should be adopted immediately.

It is an "avulsion fracture," produced by violent tension on the anterior crucial ligament. As the latter is tense in extension, the violence is a forced *hyperextension* of the knee. The portion of bone torn up is usually about $\frac{1}{2}$-inch wide, $\frac{3}{4}$-inch from before backwards, and $\frac{1}{4}$-inch thick. It is the area of attachment of the anterior crucial ligament. This portion of bone is elevated from its bed, so that it lies just above the level of the surface of the tibial head. The injury may occur in children under ten, but is most frequently seen in men between twenty and thirty. The history is that of a severe wrench. There is an effusion of blood into the joint, and pain at the line of the joint. The knee is locked so that full extension is not obtainable. With little displacement it will be locked at 170 degrees, but commonly at 150 degrees, so that the knee is 30 degrees short of full extension. There is abnormal antero-posterior movement so that the tibia can be displaced forwards on the femur. The antero-posterior skiagram shows a piece of bone in the joint, centrally placed, and this is seen in the lateral view also.

Differential Diagnosis. When there is little displacement, the lesion may be mistaken for a displaced semilunar cartilage owing to the locking. The skiagram will show the bony lesion. In an anterior crucial ligament tear alone, there is no bony block and a normal X-ray picture. In injury to articular surface of femur, tibia or patella, a fragment may be displaced and cause similar symptoms. The history in this type of case may not relate the exact type of violence. Bony block occurs, but laxity of antero-posterior movement is not present unless lateral ligaments have been torn. The X-ray film will show the hollow from which the piece of bone and articular cartilage have been detached.

Treatment. There is some divergence of opinion as to whether every case should be operated on to refix the detached piece of bone, or whether operation should be limited to those cases with considerable ($\frac{1}{4}$-inch) upward displacement.

The *non-operative treatment* consists in manipulating the knee straight under an anæsthetic and fixing it in plaster. For such a manipulation to be a success it implies that the piece of bone is pressed back into its notch and remains there. In view of such an improbability, it is my opinion that this line of treatment should be limited to patients on whom an open operation is contra-indicated, or to those who realise that, if the post-manipulative X-ray photograph shows the displacement still present, an open operation will be necessary.

By *operative treatment*, a perfect reposition and a strong knee are

obtainable, whereas with the best manipulation the piece of bone is left slightly elevated so that the anterior crucial ligament is looser than normal. Removal of the fragment of bone is to be condemned.

Procedure. A tourniquet is employed. The knee is flexed 45 degrees from the extended position. The incision, which is nearly

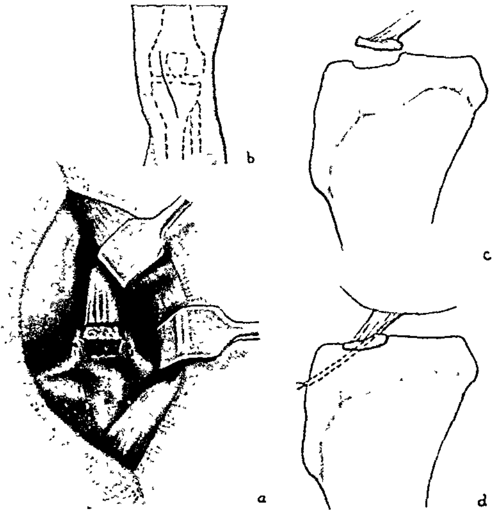

Fig. 2116.—FRACTURE OF THE TIBIAL SPINE.

(a) Shows the fragment of bone elevated from the upper surface of the tibia. Line of drill holes are indicated.
(b) Line of skin incision used for exposure.
(c) Lateral view to show how fragment is elevated.
(d) Lateral view after replacement and fixation of fragment.

6 inches long, commences above on the inner side of the patella, ½-inch from its lower border, and extends downwards parallel to the inner border of the infra-patellar ligament to just below the tubercle of the tibia. The capsule and synovial membrane are opened in the same line. A retractor is placed on the infra-patellar ligament and, if free access to the front of the joint is not likely to be obtained, the tibial

tubercle is removed with a chisel, flush with the crest of the tibia, and the ligament and patella are retracted outwards. (This is unnecessary in a child.) With a dissector the edges of the fracture are defined and the fragment is carefully elevated. Blood clot and any loose cancellous tissue is removed from the notch. The fragment of bone is fitted into the notch.

Should the assistant elevate the leg, it will be seen that the fragment will leave the notch again.

With a morse drill not larger than $\frac{3}{32}$-inch, two drill holes are made from the anterior surface of the tibia, deep to the normal position of the infra-patellar ligament, obliquely upwards and backwards as shown in figure 2416. Catgut No. 2 threaded on a needle is passed up one hole, through the attachment of the crucial ligament to the fragment of bone and down through the second drill hole (alternatively it can be passed directly through the fragment, but drilling the fragment may split it). The assistant presses the fragment home with a pair of forceps whilst the stitch is tied in front of the tibia. The knee should now be extended to see that the fragment does not move. If this does occur, it shows that the stitches are too loose.

The tibial tubercle is fixed into place with stitches or a nail. The joint and skin are closed. The limb is put in plaster with an extended knee for ten weeks. Weight-bearing is allowed after a month, but no joint movement until the plaster is removed. A window can be cut for faradic stimulation.

The Condyles of the Tibia

The condyles are fractured by forcible abduction or adduction injuries of the knee (fig. 2417). The fracture line, of necessity, runs into the knee joint, and considerable effusion of blood will usually be found. Tearing of the corresponding semilunar cartilage is a frequent complication, particularly when the outer condyle is fractured. It may be displaced, so as to lie between the broken fragment and the fractured surface of the shaft.

Displacement. The triangular portion of condyle is displaced downwards, causing irregularity of the articular surface of the tibia.

Should the fracture remain unreduced, two serious complications are likely to follow: (*a*) Gross osteo-arthritis of the knee, with corresponding diminution in the range of movement; and (*b*) Genu varum, or valgum, according to the condyle involved.

Fracture of both condyles is a rare injury, but when it happens the tibial shaft is forced between them like a wedge.

Treatment. Should great effusion be present in the joint, it may be

wise to rest the leg for a few days on a Thomas splint, bent at the knee, or on a Braun frame. A firm pressure-bandage should be applied to limit the effusion.

Reduction.

(1) *By manipulation.* An anæsthetic is given and the knee strongly abducted, for fracture of the internal condyle. The internal lateral ligament remains attached to the fragments and pulls it upwards into

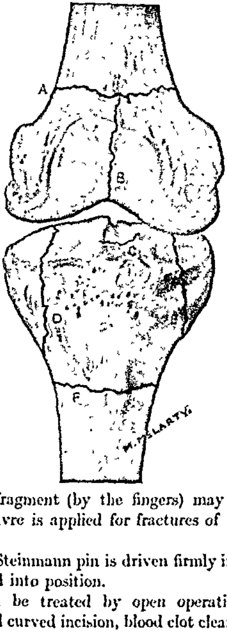

Fig 2417.—Fractures of condyles of femur and tibia. Lines indicating the types occurring singly. The fracture of a condyle of the tibia may extend more into the centre of the joint than is here shown.

position. Direct pressure on the fragment (by the fingers) may be of assistance. The reverse manœuvre is applied for fractures of the external condyle.

(2) *Should manipulation fail*, a Steinmann pin is driven firmly into the fragment, which is then levered into position.

(3) *Incomplete reduction* should be treated by open operation. The fracture is exposed by a vertical curved incision, blood clot cleared away, and the loose fragment fixed by a couple of bone pegs or a wood screw. Removal of the corresponding semilunar cartilage may be necessary.

Needless to say, exceptional care must be taken that the skin of the operation area is intact, free from blisters, and carefully prepared by a three-day preparation. During the operation the knee joint is opened and the consequences of sepsis made correspondingly serious.

(4) *Fracture of both condyles* necessitates:

(*a*) Traction in the screw-traction apparatus from a pin through the os calcis.

(*b*) Lateral compression to force the displaced fragments into position, by the hands or by the compression clamp.

After-Treatment. The fracture having been reduced, the knee is fixed in a plaster-cast extending from the buttock to the toes. The joint should be in full extension but not over-extended, and care must be taken to avoid genu varum or valgum. Antero-posterior and lateral X-ray pictures are then taken as a check of accurate reduction.

A walking-iron may be applied and the patient allowed to get about after a week. The plaster should remain on for ten weeks.

Should it be decided to treat the case by massage and mobilisation, the cast should be bivalved after four weeks. Great care must be exercised, as the deformity is liable to recur, especially if weight-bearing is allowed too early without adequate support.

If traction fails to reduce the displacement, open operation is advisable. The fragments are aligned correctly and held in place by a metal screw and bolt. This is passed transversely about ½-inch distal to the joint. The advantage of the bolt is that, as it is screwed tight, the fragments are compressed. It is advisable to remove the bolt about eight weeks after the operation.

Shaft of the Tibia

The common site for fracture is in the middle third. Two types occur frequently: (1) The *transverse* fracture, due to direct violence and often associated with a skin wound; a large proportion of these result from motor-cycle accidents in young adults. (2) The *oblique* fracture, due to indirect violence or torsion. If a skin wound exists in this type, it is due to the sharp bony point of the lower fragment being forced outwards and not to the causative violence.

In children, the fracture is almost invariably of the *spiral* type, with little or no displacement. Fracture of the *fibula* is commonly associated. In the transverse type of fracture, the fibula is usually broken at or about the same level as the tibia. In the oblique type, the break in the fibula is 2 or 3 inches higher than the tibial fracture, but fracture of the neck of the fibula is often associated with fracture below the middle of the tibia.

Deformity. In adults, this is often considerable.

(1) *Transverse fracture.* (*a*) *Fibula intact*: little or no shortening; lateral displacement or angulation. (*b*) *Fibula fractured*: shortening and lateral displacement with angulation.

(2) *Oblique fractures.* (*a*) *Fibula intact*: angulation or lateral displacement. (*b*) *Fibula fractured*: shortening, in addition.

(3) *Spiral fractures in children* (*fibula often intact*): deformity usually limited to *slight* shortening and lateral displacement,.

Complications.

(1) *Open fracture* is by far the commonest complication in adults. If the skin wound be a mere puncture, as it frequently is, many of these cases can be treated as if they were closed fractures, and run the normal course of a closed fracture. Should sepsis supervene, however, local osteomyelitis with sequestra formation will greatly delay the time of union.

(2) *Comminution* is frequently found in the transverse type due to direct violence. A triangular portion of bone may be detached or a number of smaller fragments may be present. Some may undergo necrosis, if torn from the attached muscle and periosteum.

(3) *Malunion* is seen more commonly than it should be. This may be attributed to faulty reduction, or to inefficient fixation for a sufficiently long period. Removal of the plaster-cast for " massage " before union is firm is another frequent cause.

The most serious cases of malunion are those with angular deformity. Slight shortening is of less importance. Sometimes a large, unsightly mass of callus forms around one of the detached fragments. Its presence is of no consequence except from the cosmetic point of view.

(4) *Non-union* results from: (*a*) Sepsis; (*b*) Over-traction with interposition of soft parts; (*c*) Insufficient splintage; and (*d*) Malposition.

Treatment.

(1) *Children.* Should displacement be present, correction under an anæsthetic by manual manipulation is usually all that is required. It is rare that the need for continuous traction arises. Fixation is by a well-fitting plaster-cast, extending from mid-thigh to the tip of the toes. The *knee should be flexed* 15 degrees, with the foot at right angles. Accuracy of reduction should be checked by antero-posterior and lateral X-ray films taken through the cast.

In small children it is well to protect the heel of the plaster with a pad of felt or to apply a wooden " sole " to the cast, otherwise the plaster will be found soft and cracked after a few hours of play by the child.

In older children a walking-iron may be fixed as soon as the cast is hard. In oblique fractures, however, the child should not bear weight on the leg for a month, as the risk of over-riding of the fracture inside the cast is great.

All splinting may be removed in from 6 to 8 weeks.

Note. It should be an *invariable* rule that *all* cases of recent fracture treated in plaster-of-Paris should be inspected within twelve hours of application of the cast. Better still if they can be admitted to hospital for twenty-four hours. Neglect of this precaution may result in pressure sores, swollen limbs, ischæmia or gangrene, apart from intense pain to the patient.

At the slightest suggestion of swelling or blueness of the extremities, the cast must be split open and the limb elevated It is important to remember that wadding or bandage beneath the plaster should also be cut.

(2) *Adults.* Three methods are available:

(*a*) Manipulative reduction followed by plaster-cast.

(*b*) Reduction by means of the screw-traction apparatus of Böhler or Watson Jones, followed by plaster-cast.

(*c*) Continuous skeletal traction on a Braun frame for two or three weeks. Later, a plaster-cast.

(*a*) If the case is seen early, before much swelling has appeared, it is occasionally possible to "hitch" the fracture under an anæsthetic, and to fix it immediately in plaster. It is only possible to "hitch" transverse fractures in this way and the method is of limited application.

(*b*) Screw traction is particularly useful in oblique fractures. The essential points in the method are:

(i) The shortening is overcome by mechanical traction, and lateral displacement is corrected by pressure with the hands at the site of the fracture.

(ii) The knee is flexed to a right angle in order to relax the calf muscles. This is an essential step. Counter-traction is made by the bar of the apparatus against the lower part of the thigh, just above the popliteal space.

(iii) When reduction is satisfactory, a plaster-cast is applied and allowed to "set" *before* the traction is released (see Vol. II, figs. 1949 and 1950).

Method. The patient is anæsthetised, and the heel prepared and painted with iodine. A Steinmann pin is inserted through the os calcis, and a stirrup applied. An assistant makes manual traction from the stirrup, while the leg is lifted on to the traction apparatus. The bar for the knee must be well padded with felt or sorbo rubber, and should be adjusted to such a height that the knee, when resting upon it, is flexed nearly to a right angle. The stirrup is attached to the hook of

the traction screw. It is convenient to have a spring balance between stirrup and hook, so that the actual traction may be read off in pounds, but this is not essential. The screw is gradually tightened, and a careful check is kept upon the measurement of each tibia (from the upper end to the internal malleolus. Both legs should be in the same position while the measurement is taken.) If the fracture can be "screened" in the theatre, so much the better.

When all shortening has been overcome, the site of the fracture is massaged in order to remove any œdema, and the subcutaneous surface of the bone is palpated. Any lateral displacement is corrected by pressure with the two hands from either side.

The leg, if hairy, is smeared with vaseline to prevent adhesion of the plaster.

A plaster slab is made, 6 inches wide and of sufficient length to extend from the knee to the toes, as measured along the back of the leg. It is applied directly to the skin, without padding, and bandaged along the calf with smooth turns of flannel bandage. That portion for the foot is now moulded round the heel and cuts are made at the corners to make it lie smoothly. The foot portion should be held by an assistant until hard. The corners may be made quite strong by splitting the layers of plaster and dovetailing them together alternately.

When correctly applied, there should be a strip of skin uncovered by plaster, about 2 inches wide down the front of the leg. A thin layer of wadding is now laid over this gap in the plaster. Finally, two or three plaster bandages are applied in the ordinary way so that the whole leg from knee to foot is encased. When the plaster is set, traction is released and the apparatus removed. The knee is now protected by wadding and the cast continued up to the middle of the thigh. The pin is removed through a small hole in the cast.

The position of the fracture is checked by means of X-rays. When this method is used, the patient may walk in a few days with a walking-iron fixed in the plaster.

Modifications.

(i) It is sometimes recommended that a complete plaster-cast be applied without the preliminary slab and wadding. If this is done, it is *essential* to split the cast immediately along the anterior surface throughout its whole length, as considerable swelling of the limb may occur after screw traction is released.

(ii) Instead of carrying the cast above the knee, a firm hold on the upper fragment may be obtained by inserting a second pin through the upper end of the tibia. In this case both pins are left *in situ* and

incorporated in the plaster. As an alternative to the pin through the os calcis, one may be placed through the lower end of the tibia.

(c) *Continuous traction.* This should be used:

(i) Where screw traction has failed. (In this case the plaster slab *is not applied, but the fractured limb is immediately transferred to a* Braun frame and continuous traction applied.)

(ii) As an alternative to screw traction.

(iii) Where the fracture is complicated by a large wound or by sepsis.

(iv) In late cases, in which deformity has not been corrected at the outset.

Method. The patient is anæsthetised, a pin is inserted through the os calcis, and a stirrup then applied.

The limb is laid upon a Braun frame and a weight of 10–15 lb. attached to the stirrup. After a few days a set of X-ray films is taken and any necessary adjustment made. Special care is taken that the limb is not over-extended and, when shortening has been overcome, the weight is reduced. Usually in from 3–6 weeks the callus is sufficiently firm to allow the application of a plaster-cast. This should be applied in the manner already described, but the layer of wadding may be replaced by one turn of flannel bandage. The slab should be applied *before* traction is released, the slings on the Braun frame being removed for the purpose. When hard, the limb is lifted clear of the frame, stirrup and pin are removed, and the plaster-cast is completed.

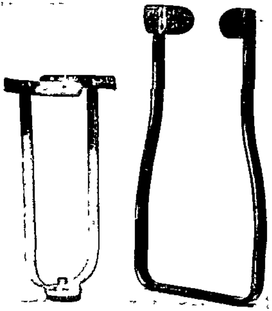

Fig 2418.—Two types of walking iron or stirrup. The rubber pad is a Phillips rubber heel, attached by a bolt.

Should a wound be present, "an inspection window" may be cut in the plaster.

After-Treatment. The majority of these fractures should be treated by the "ambulatory method" and a walking-iron fitted as soon as the cast is hard (fig. 2418). Patients can walk quite satisfactorily after a little practice, even when the knee has been included in the plaster. The use of crutches should be discouraged, but one or two stout walking-sticks are necessary as a precaution against falls.

With elderly or feeble patients it is difficult or impossible to carry out ambulatory treatment, and the wiser course is to "bivalve" the cast as soon as union is firm and to treat by massage, movements, and assisted exercises.

The time necessary for complete union varies enormously. Closed fractures in healthy young adults should be firm in three to four months, but manual labourers rarely return to work under six months.

Lower Third of the Shaft of the Tibia

A common fracture, due to indirect violence, is at the junction of the middle and lower thirds of the tibia. This oblique fracture—termed *flute en bec*—is associated with a fracture of the neck of the fibula.

Displacement usually occurs and consists of angulation, rotation, and overlap with little lateral displacement.

Reduction by manipulation is not satisfactory. With skill, skeletal traction with a posterior slab may produce complete reduction in perfect position. It is often difficult to control the tendency of the lower fragment and foot to rotate.

This fracture is one in which a perfect end-result can be achieved by an open reduction, carried out preferably a few days after the injury. The approach is easy, and the bones can be replaced accurately and fixed by a six-screw Lane's plate, placed on the surface of the tibia facing the fibula. If the plate is placed on the subcutaneous surface, it will have to be removed later. The use of a plate is preferable to that of a band, more accurate and firmer than wire, and a simpler procedure than a bone graft. The limb is put into a light plaster. This is changed when the stitches are removed, in order to get a more tightly-fitting plaster over less wool. Weight-bearing is not allowed for eight weeks. Splinting is usually advisable for twelve weeks from the date of operation. As a rule, callus formation is neither rapid nor extensive after this operation.

In children, a partial fracture of the tibial shaft, about 2 inches above the ankle joint, is often seen, the fibula being fractured at the same level.

Deformity consists of considerable angulation in the antero-posterior plane. Manual correction under an anæsthetic is usually easy.

Fig. 2419.—Bone graft of the tibia for fibrous malunion. The site of fracture has been exposed, and the periosteum retracted. The dotted lines indicate the line of division of the bone with the saw.

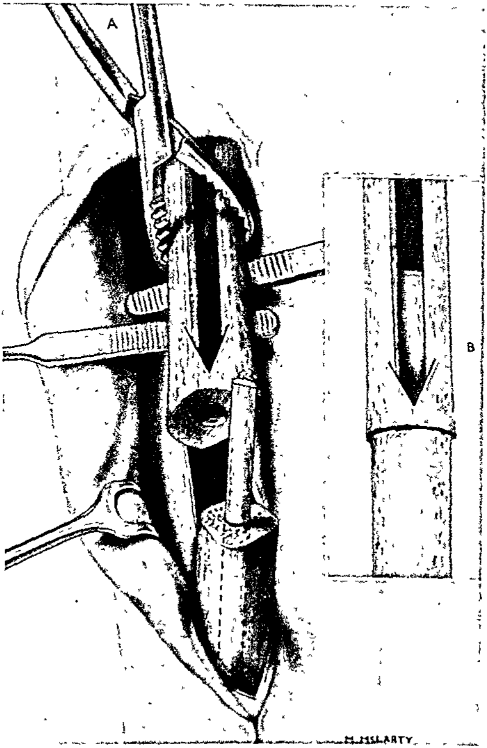

Fig. 2130.—Bone graft of the tibia. A. The graft has been cut from the proximal part of the tibial shaft and has been inserted into the medulla of the distal fragment with two inches protruding into the wound. Note that a small spicule is left at the end of the proximal fragment. B. The fragments have been brought into alignment and the graft is shown lying in the medulla. A medullary graft in each end of the bone is only possible when the shaft has been shortened. It fits more tightly than an intra-medullary fixation in the distal fragment and lateral inlay above.

Non-union of the Shaft of the Tibia

This is seen in the middle and lower thirds of the bone. Transverse fractures, which are not supported for a sufficiently long time, and compound fractures, when there has been separation of the fragments, are notable for this complication. Often it is not recognised until the patient has been walking and angulation occurs, associated with pain. A false joint seldom forms in this situation, in contrast with the humerus, and fibrous union is generally present.

Treatment. Operative treatment is employed as a routine. If this is contra-indicated or refused, the patient is fitted with a moulded leather splint, covering the leg and foot.

The operative treatment may be:

(1) Drilling holes through the ends of the fractured fragments,

(2) Bone-grafting.

In recent years the former has had a number of advocates.

(1) The technique is simple. An inch of bone above and below the fracture is exposed. With a morse drill, $\frac{1}{8}$-inch, a number of holes are made through the fibrous union and bone, and others into the bone around the fracture. Some surgeons employ weight-bearing immediately, but others prefer to keep the patient recumbent and prescribe heat and massage to encourage bone formation. This procedure produces union in certain cases, but it is considered that the routine procedure should be:

(2) Bone-grafting. An 8-inch incision is made along the outer side of the subcutaneous border of the tibia. The periosteum is incised above and below the site of the fracture and separated from the bone. This sheath is then separated with care from the area of fracture, until the two fragments of bone can be split apart with an osteotome and pointed out through the wound. The fibula is then fractured by manipulation, or by a short incision and division with an osteotome 3 inches above the ankle joint. The fractured ends of the tibia are trimmed, so that all the bony tissue appears healthy. A mechanical saw is employed to cut a graft from the upper fragment. This is passed into the medulla of the lower fragment and allowed to lie in the upper fragment as a *lateral inlay*, or in the medulla, with a bridge to hold it in place (see fig. 2420). The assistant pushes the foot up so that the fractured surfaces of the tibia are in contact. The fit should be so tight that no displacement occurs when the ankle or leg is moved about. If there is movement, fixation with small pieces of bone or circular loops of catgut must be added. The wound is closed and plaster splinting applied.

After-Treatment. The stitches should be removed through a window, and the limb not disturbed for eight weeks. At the end of that time a tightly-fitting plaster can be employed, and if the X-ray film shows new bone formation advancing, the patient may walk with an iron in the plaster. Four months' plaster is usually advisable. The results of this operation are very satisfactory.

Bone-grafting of the humerus for non-union and pseudarthrosis may be carried out on similar lines, or by the use of a tibial graft placed intra-medullary. The end-results show that a number do not obtain bony union, probably owing to the difficulty of firm fixation by external splinting, even if a plaster surrounding chest and arm is employed.

FIBULA

Fracture of the fibula neck by direct violence, complicated by injury to the external popliteal nerve, is of rare occurrence. Treatment of the nerve injury is the primary consideration.

Fracture of the shaft of the fibula alone does not affect the function of the leg, so that the local tenderness may be thought to be a bruise only. Fibula "springing" is painful, and the fracture is seen in the X-ray film. The patient is allowed to walk after a few days' rest and support by strapping. Heat and massage may be employed.

FRACTURES ABOUT THE ANKLE JOINT

These are conveniently classified into two main types:

(1) *Abduction fractures.*
(2) *Adduction fractures.*

Although a rotatory movement occurs at the time of fracture, the introduction of this word into the nomenclature of ankle fractures is confusing, and is therefore purposely omitted here. They are caused by indirect violence. The patient's weight as he falls is applied as a torsional force to the ankle joint whilst the foot is in contact with the ground.

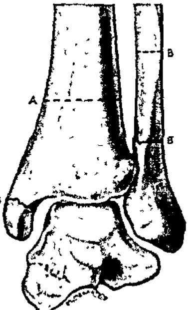

FIG. 2121.—ANTERO-POSTERIOR VIEW ILLUSTRATING A, SITE OF FRACTURE IN LOWER END OF TIBIAL SHAFT, NOT INFREQUENTLY SEEN IN CHILDREN; B, SITES OF FRACTURE OF INTERNAL MALLEOLUS AND FIBULA IN ABDUCTION (POTT'S FRACTURE).

Abduction Fractures (Pott's Fracture)

The foot is everted and rotated outwards in relation to the tibia. The astragalus impinges against the external malleolus, and the *fibula* is fractured in an oblique manner just above the tibio-fibular ligaments. The line of fracture is from

behind downwards and forwards. It may be almost invisible in an antero-posterior X-ray picture, but it is plainly shown in a lateral view. The internal lateral ligament may be torn or a flake of bone be pulled from the tip of the internal malleolus.

Deformity. In mild cases there is none. When present, the foot is in plantar flexion and slight eversion at the ankle joint.

Lateral displacement of the astragalus in the tibio-fibular mortice is recognised in the X-ray film by the widening of the joint space on the inner side (i.e. between the astragalus and internal malleolus).

Fracture-dislocation.

Partial or complete dislocation of the astragalus may occur in cases where the causative violence has been exceptionally severe, the foot being carried in an outward, backward or upward direction :

(*a*) The posterior lip of the articular surface of the tibia may be fractured. This will be observed in a lateral X-ray film as a triangular fragment detached from the posterior surface of the tibia. As a result, backward displacement of the astragalus may be present.

(*b*) The inferior tibio-fibular ligaments may be ruptured, so that marked outward displacement and eversion of the foot occurs.

(*c*) In rare instances, when the patient has fallen from a height on to the heel, the tibio-fibular ligament may be ruptured by the astragalus acting as a wedge between the two bones. Upward displacement of the whole foot results, together with eversion.

This injury is known as *Dupuytren's fracture.*

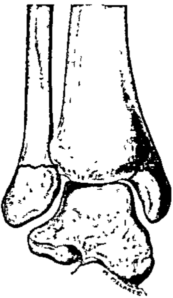

Fig. 2122.—Antero-posterior view of typical adduction fracture.

Adduction Fracture

In this type the foot is inverted in relation to the tibia. The astragalus is forced against the internal malleolus, which is fractured obliquely across the base. The external lateral ligament may be torn, or the fibula fractured transversely at the level of the articular surface of the tibia, as if it had been snapped across the sharp edge of the tibia at this level. Inversion and internal displacement of the astragalus will result.

Diagnosis. The differential diagnosis from a "sprained" ankle is not always easy. In many "sprains" the chief point of tenderness lies over the external lateral

ligament rather than over the malleoli. "*Springing*" the fibula against the tibia by firm pressure between the fingers and thumb may be a valuable sign if pain is elicited at a distance from the point grasped. Finally, it should be remembered that, as in injuries of other parts, all cases in which the diagnosis remains in doubt should be examined by X-rays.

Treatment.

(1) *Fracture without displacement.* (Abduction or Adduction.) (Fig. 2423.) A lightly-padded plaster-cast is the best method of fixation. Alternatively, the "slab" method described under Fracture of the Tibial Shaft may be employed. Much swelling is unlikely, but it is wise to keep

Fig. 2423.—SKIAGRAMS OF TYPICAL ABDUCTION FRACTURE WITHOUT DISPLACEMENT.

the foot elevated for a day or so. Subsequently, a walking-iron is fitted and the patient is encouraged to walk, using sticks and not crutches. If much œdema is already present, this should be massaged away before application of the cast.

Special points in applying the plaster: (*a*) The knee must be flexed to a right angle over a support or held by an assistant. (*b*) The foot should be at a right angle with the tibia, the toes being held by an assistant. (*c*) The forepart of the foot should be "square" and *not forcibly inverted.* (*d*) While the cast is setting, *the os calcis is inverted by pressure on the outer side.* (*e*) *The plaster should extend from just below the knee to the tip of the toes.* It may be trimmed away on the dorsum of the foot for an inch to allow free movements of the toes.

(2) *Abduction (Pott's Fracture) with Displacement.*

(a) *Manipulative reduction.* As a rule, the more gross the displacement the easier the reduction, provided comminution has not occurred. A general anæsthetic is always required, gas or gas and oxygen alone giving insufficient relaxation. Alternatively, local anæsthesia may be employed in cases unsuitable for general anæsthesia.

The knee is flexed to relax the tendo Achillis and the foot is brought up to a right angle. Firm pressure is made with the hand on the outer side of the os calcis, in order to force the astragalus well "home"

Fig 2424.—Skiagrams of abduction fracture showing incomplete reduction. Some tilting and external displacement of the astragalus remains. The lateral view shows little displacement.

against the internal malleolus. Any backward displacement is corrected by lifting the foot forward, counter-pressure being made on the anterior surface of the tibia. An unpadded plaster slab is applied in the manner already described, firm pressure being made on the outer side of the os calcis until the plaster is hard. Care is taken that the foot is at a right angle with the leg.

The cast is then completed and the ankle should be immediately examined by means of X-rays. If reduction is not satisfactory, the cast should be removed and a fresh attempt made.

Common Causes of Failure to obtain Satisfactory Reduction :

(i) Failure to attempt reduction at the earliest possible moment. Attempts made hours or days after the injury are doomed to failure, owing to the presence of blood clot between the fragments.

(ii) Insufficient muscular relaxation for a period long enough to allow firm "setting" of the plaster-cast.

(iii) Neglect to flex the knee.

(b) *Operative reduction.* In selected cases where other means have failed to obtain accurate reposition, the question of open operation should be considered. Briefly, the possibilities are: (i) Reconstruction of the ankle joint; or (ii) Arthrodesis of the ankle joint.

Reconstruction. In Dupuytren's fracture, or where the tibio-fibular ligaments have been ruptured, the bones are best fixed together by bolts or screws, within a week of the injury. Where deformity persists after attempts at reduction by other means, open reduction should be undertaken, provided this can be done within three months of the injury.

The scope of the operation embraces exposure of the internal malleolus on the inner side, and of the fibula through a separate incision on the outer side of the joint. Old blood clot and fibrous tissue is cleared away. It is often sufficient to maintain accurate replacement of the astragalus by fixation of the fibula fracture with a four-hole Lane's plate. This may be subsequently removed. In other cases, it may be necessary to fix the internal malleolus by means of a screw passed up into the tibia.

Needless to say, the earlier this operation is undertaken, the greater the likelihood of accurate anatomical replacement and the less the chance of subsequent arthritis. The method is deserving of consideration in any "difficult" fracture in a young adult.

Arthrodesis. In late cases with malunion, severe valgus deformity with pain is often experienced. Before deciding upon operation, it may be well to try a surgical boot, fitted with valgus iron and T strap. Occasionally a moulded leather splint, fitted accurately to the ankle and worn inside the boot, may give relief.

Should conservative methods fail, the question of arthrodesis must be considered.

Treatment of Adduction Fractures with Displacement.

The general principles of treatment already laid down should be employed. Modification in the type of manipulation is necessary owing to the reverse displacement from the abduction fracture.

After Treatment. The majority of severe fractures require fixation in plaster for ten weeks. If the injury is a crack without displacement, six or eight weeks may suffice. The "ambulatory" method should be employed wherever practicable. Mild cases may walk, using the walking-iron, within two or three days. In severe cases two or three weeks of recumbency may be required before walking

is allowed. When the plaster is removed, a firm elastoplast or zinc-gelatine bandage should be applied immediately and worn for several weeks. By this means much œdema and resulting discomfort is avoided.

The heel of the shoe should be wedged ¼-inch on the inner side for at least three months.

Massage and physical treatment is valuable in elderly patients and in those with much œdema and stiffness, but should not be employed until the end of the period of ambulatory fixation Early physical treatment should be reserved for those cases too old or feeble to manage the walking-iron, in which case the plaster-cast is "bivalved" at the outset. (The period of disability after severe fracture-dislocation of the ankle in working men is, according to the British Medical Association Report of 1935, about *forty seven* weeks, and when treated in organised clinics about *eleven* weeks.

Separation of the Lower Tibial Epiphysis.

A severe abduction injury at the ankle in a child between the ages of ten and fifteen usually causes an oblique fracture of the fibula (similar to that of Pott's fracture) and a "separated epiphysis" of the lower end of the tibia. The foot may be dislocated backwards at the ankle joint or move backwards with the epiphysis. The line of tibial injury is through the plate separating epiphysis from shaft, with a fracture of the posterior lip of the tibial shaft. The signs are those of Pott's fracture.

Treatment consists in reduction and fixation under anæsthetic as soon after the injury as possible. The reduction is a similar manipulation to that described for abduction fracture with displacement. An unpadded posterior plaster splint is applied to the calf and sole of the foot, extending from below the knee to the tip of the toes. A flannel bandage is wound round the limb and splint. After a layer of wadding has been placed over the front of the limb and ankle, circular turns of plaster bandage cover the whole, and a metal walking-iron is fixed on. The ankle is examined by X-rays to check a satisfactory reduction and the limb is kept elevated for forty-eight hours. If the toes swell much, the plaster must be cut straight up the front and folded out. If the splint is comfortable, walking is allowed in a week. The plaster is not removed for ten weeks, unless it is loose.

If early reduction has not been carried out, open reduction may be required. Fixation by internal splinting should be avoided if possible.

ASTRAGALUS

Two types of fracture occur: of the neck, and of the body.

(1) *Fracture through the neck* is the more common type. The body of the bone is rotated, its fractured surface looking downwards. Cor-

rection may be attempted by forcible plantar flexion of the foot, over a wedge. The foot is then put up in a plaster-cast for six weeks, but this time is prolonged if the union, as shown by X-ray examination, is not firm.

(2) *Compression fracture* should be treated in the screw-traction apparatus, traction being made in the line of the tibia. Immobilisation in plaster is necessary for ten weeks.

If, some months after the fracture has united, there is persistent pain and swelling, arthrodesis of the ankle or subastragaloid joint, or removal of the astragalus may be advisable.

Small fissures and chips, associated with fracture-dislocation of the ankle joint, call for no special mention.

OS CALCIS

Injuries of the os calcis constitute about 2 per cent of all fractures. The accident is most common among window-cleaners and painters, owing to their liability to fall from a height and land on their feet. Bilateral fracture is common.

Types.

(1) *Compression fractures*, comprising about 90 per cent of all fractures of the os calcis.

(2) *Fracture of isolated processes.* The sustentaculum tali and peroneal tubercle are those most often affected.

(3) *Avulsion fractures.* Sudden and forcible contraction of the tendo Achillis, causing avulsion of a portion of the posterior surface of the bone, is a rare injury. (The so-called "beak" fracture consists of a portion of bone detached from the posterior and upper angle of the os calcis by compression. It becomes displaced by contact with the tendo Achillis, but, lying as it does above the insertion of this tendon, this is not a true avulsion fracture.)

(1) *Compression fractures.*

Important considerations. When a compressing force is applied to the heel, the os calcis tends to be pronated or everted. Vertical compression of the bone causes a lateral broadening, and the outer surface of the bone is forced outwards, forwards and upwards.

In addition, a fracture is commonly present at the neck, between the articular facets dividing the bone virtually into an anterior and posterior portion.

Two muscle forces which are responsible for the production of deformity act upon the posterior portion of the os calcis: (*a*) The tendo Achillis; and (*b*) the short muscles of the foot (see fig. 2425). The

former tends to produce angulation of the posterior fragment upon the anterior, the angle being open upwards. In effect, the posterior portion comes to lie more nearly on a level with the articular facets instead of below them, and the posterior pillar of the longitudinal arch of the foot is lost. The latter force is responsible for "impaction" or shortening of the bone as a whole.

The deformity produced by the pull of the tendo Achillis may be conveniently measured by what Böhler calls the "tuberosity-joint angle"

A line is drawn from the highest point on the upper surface to the anterior angle, and another line from the highest point to the upper part of the tuberosity. In the normal bone these lines will meet at an angle of approximately 150 degrees, the complementary angle being about

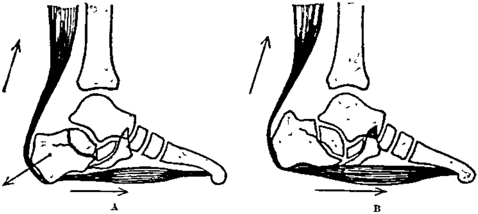

Fig 2425.—Diagrams show: A. Muscle forces acting in compression fracture of os calcis. B How traction overcomes the muscle pull.
(*After Böhler.*)

30 degrees. This smaller angle is the more convenient to measure and is referred to as the "tuberosity-joint" or "salient" angle.

After severe fractures of the os calcis, the angle becomes less or may cease to exist when the two lines become parallel with each other.

Diagnosis. The history of a fall, pain and swelling of the heel, and inability to walk make it clear that the injury is to the os calcis or astragalus, and not to the lower end of the tibia and fibula. Special attention should be given to the broadening of the heel and the abnormal appearance of the posterior pillar of the foot. Marked limitation of inversion and eversion will be present. If the case is seen late, the signs will be masked by swelling.

The external malleolus is sometimes fractured at the same time.

X-ray diagnosis. Good films are essential. Three views are necessary: in addition to the usual antero-posterior and lateral views

a plantar-dorsal view is required. This is taken by placing the heel upon the X-ray film while the patient forcibly dorsiflexes the foot by means of a loop of bandage. The axis of the X-ray tube is directed at an angle of 45 degrees to the plantar surface of the heel. In doubtful cases, similar views of the normal os calcis should be taken for comparison.

Prognosis. In all severe compression fractures and in fissured fractures running into the subastragaloid joint the prognosis is serious. Persistent pain, œdema, subastragaloid arthritis, and flat foot are common sequelæ. The earning capacity of a labouring man is greatly reduced and heavy compensation claims may be involved, the period of disability being of many months' duration.

Treatment. In the past, the results of treatment of these fractures have been poor, no matter what method has been employed. The question as to the best method is still largely undecided until each has been given a further period of trial. It must be remembered that the majority of these fractures occur in working men who are entitled to compensation, and that while undoubtedly a great deal of pain and deformity may persist after treatment, there is usually in addition the added psychological element, which is very difficult to assess.

(1) *Fractures with Little or No Deformity—fissured fractures.*

The œdema is massaged away and an unpadded plaster-cast applied. The limb is elevated, and special vigilance with regard to after-swelling must be exercised. In a few days a walking-iron may be applied, and the patient allowed to walk. The cast should be retained for at least eight weeks.

(2) *Compression Fractures with Deformity.*

As with other fractures, an attempt should be made to correct deformity and to restore the bone to as normal a condition as possible.

(*a*) *Bone broadened, but no alteration of salient angle.* A local or general anæsthetic is given, and the bone restored to its normal contour by means of a compression clamp or *redresseur* (fig. 2126). This consists of a screw clamp similar to those used by cabinet-makers, and fitted

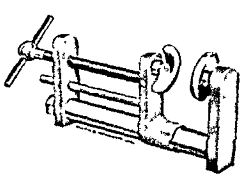

Fig. 2126.—Compression clamp for reduction of crush fractures of the os calcis.

with padded convex jaws. The average measurement across the os calcis is about 35 mm. and the jaws of the clamp should not be approximated more than this amount. The clamp must be removed immediately the requisite compression has been made, or sloughing of the skin may result. A plaster-cast is then applied and treatment carried out as already described.

(*b*) *With loss of salient angle.* This is the common severe type of fracture. The distorting muscular forces are the tendo Achillis and the short plantar muscles pulling at right angles to one another. These two forces may be overcome by a single force acting in the line of the resultant of these two forces.

The screw-traction apparatus is required. A pin is inserted *far back* through the os calcis and a traction stirrup applied. A second pin is then driven through the tibia a hand's breadth above the ankle joint, and its stirrup hung to the upright of the traction apparatus. The knee is bent to a right angle over the bar of the apparatus and traction is made in the line of the tibia. The screw traction is now released and the traction bar lowered to make an angle of 45 degrees with the tibia. Traction is applied at this angle for a few minutes. The compression clamp is applied to overcome broadening of the bone. A plaster-cast is put on, which incorporates the two pins. When hardened, the traction is released. The two pins incorporated in the cast

Fig. 2427.—Skiagram showing unreduced compression fracture of os calcis.

Fig. 2428.—The same fracture as shown in *Fig.* 2427 after reduction, with the leg and foot fixed in plaster-of Paris.

serve to hold the fragments of os calcis in position. (It is useful to protect the ends of these with corks.)

After-Treatment. The limb should be placed on a Braun frame under a radiant heat cradle. Constant observation of the toes for deficient circulation should be made during the first twenty-four hours. After a week, a walking-iron may be applied.

The cast and pins should be removed in eight to ten weeks, unless persistent pain or a raised temperature necessitates an earlier removal. Subsequently, a firm bandage should be worn and physical treatment instituted. Alternatively, continuous skeletal traction for ten to twelve weeks may be employed, using a Braun frame. In elderly persons or where the patient cannot be kept under strict supervision, this latter method is to be preferred.

(3) *Displaced processes* may be restored to position by the compression clamp, before application of a plaster-cast and walking-iron. This should be worn for eight weeks.

(4) *Avulsion Fractures.*

Fixation in plaster is required, and in rare instances with considerable displacement operative fixation is necessary.

OTHER TARSAL FRACTURES

These fractures consist chiefly of small chips of bone broken from the navicular or cuboid. Special mention must be made of fracture of the *tuberosity* of the *navicular* which, in the absence of suitable treatment, is liable to lead to severe flat foot, owing to a gradual sinking down of the head of the astragalus.

Displacement is usually slight and accurate diagnosis must be made from the X-ray films.

It should be appreciated that the tuberosity of the navicular may remain as a separate ossicle throughout life. On this account the condition is sometimes mistaken for a fracture.

Treatment. The foot is immobilised in a well-fitting plaster-cast. Great care is taken to mould the plaster under the longitudinal and transverse arches accurately, and to extend it to the tips of the toes. The cast should be worn for at least six weeks, but the patient may walk on a stirrup after the first few days.

Fracture-dislocation may occur, especially in the tarso-metatarsal area. In the event of displacement, an attempt at reduction should be made. This may not be difficult, but there may be a tendency for the displacement to recur.

If manual traction is not successful, the following line of treatment may be adopted:

(1) Traction is applied in the longitudinal axis of the foot by

means of a pin inserted through the os calcis, and piano-wire loops inserted through the tips of each toe, after the manner of applying traction for fracture of the metacarpals. A modified form of screw-traction apparatus may be used.

(2) While the foot is under traction the displaced bones are manipulated into place by the fingers, and a plaster-cast applied. When hard the traction is released. The period of immobilisation should be ten weeks.

METATARSAL BONES

The bones are usually fractured by direct violence. In the neck and proximal end, the break is more or less transverse, but the shaft is commonly fractured obliquely. *Deformity* may be gross, and consists of overlap with lateral or vertical displacement. Severe disability is likely to follow inadequate treatment.

Special mention must be made of two types of fractures:

(1) *Oblique fracture of the base of the 5th metatarsal*, which is liable to be confused with an extra epiphysis which is sometimes present—the os Vesalii.

(2) The so-called "*march fracture*" *of the neck of the 2nd or 3rd metatarsal*, caused by excessive strain as in strenuous walking. If an X-ray film be taken as soon as pain is complained of, a minute fissured fracture may be detected. The condition is usually not recognised until a mass of callus has formed.

Diagnosis. Apart from radiology, two points are worthy of special attention in deciding whether or not a fracture is present:

(1) Pain elicited by *traction* on the toe.

(2) Pain elicited by squeezing the foot from side to side. Mere tenderness on local pressure is apt to mislead in the differentiation between a severe bruise and a fracture.

Sometimes a patient does not seek treatment for 3–4 weeks after the occurrence of a march fracture. After such an interval, there is œdema on the dorsum of the foot, and a palpable spindle-shaped swelling of the affected bone.

Treatment. Displacement should be corrected by manipulation under anæsthesia, or the method of traction outlined above may be employed. Occasionally, continuous traction from the wire loops may be necessary.

Immobilisation is by plaster-cast and walking-iron, special attention being given to the moulding of the arches.

The cast should be retained for 6 to 8 weeks, even when the diagnosis is not made until some weeks after the injury.

After-Treatment consists of the wearing of an elastoplast bandage to limit œdema ; an arch-support may be necessary and a course of physical treatment is advisable.

PHALANGES

These are caused by direct blows or run-over accidents.

Type. That of the *terminal phalanx* is often comminuted and may be associated with laceration of the nail-bed. The fracture is frequently " open ", and when this is the case, the nail should be removed and the patient put to bed until the wound is healed.

The toe may be rested on a short malleable iron splint.

All that is necessary in a closed fracture is to strap the toe firmly with adhesive plaster, and to add a short splint as a warning to the patient that he must walk on the heel. Four weeks is usually sufficient for union.

Transverse fracture of the proximal phalanx is liable to be complicated by angular deformity. This should be corrected by manipulation. On occasions, continuous traction from a wire loop may be necessary to maintain good alignment. The best method is to encase the ankle in a plaster boot, and to make traction from a wire loop incorporated in it.

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PART XXIV

EYE

by

F. A. Williamson-Noble

EYE

CHAPTER I

Affections of the Eye

METHODS OF EXAMINATION

In the interests of clarity it is assumed in this section that a male surgeon is examining a female patient. The importance of taking a history is obvious, and according to the patient's complaints one or more of the following methods will be required:

(1) In a room well lit by daylight let the patient face the window and direct her to look straight ahead. Note the presence or absence of redness or secretion in the bulbar conjunctivæ, lids and their margins. Observe the reflection of the window in the cornea, and direct the patient to look in various directions so that the whole cornea is examined. Any irregularity in its surface will be at once apparent by causing distortion in the reflection. Test the direct and consensual pupil reactions to light by shading the eyes and uncovering them. Then direct the patient to look at the tip of her nose and observe whether the pupils contract.

To examine the palpebral conjunctiva, direct the patient to look upwards and pull the lower lid down, when it is easily everted and the conjunctiva is seen. The lower lachrymal punctum will also be visible, and pressure over the median palpebral ligament will cause regurgitation of pus through it, if there be dacryo-cystitis. The lid is now allowed to go back and the patient directed to close and open her eyes. The position of the lids should be examined for entropion and ectropion, and particular attention should be given to the lower punctum to make sure it is pointing towards the eye and not upwards. Trichiasis should also be looked for at this stage.

To examine the under-surface of the right upper lid, the patient must direct her eyes downwards. The surgeon places the ulnar border of his index finger along the upper lid near its margin and his thumb on the lower lid. By exerting slight pressure the lower lid is slid under the upper and eversion is completed by moving the thumb upwards. For the left eye the surgeon employs the fingers of his right hand in a similar manner. If the fornix has to be examined, the upper lid is held everted by the index finger and the bulb of the eye is pressed back

by the thumb which is replaced on the lower lid. If this is not successful, the end of a glass rod can be carefully slipped under the upper edge of the tarsal cartilage of the everted lid and a double eversion performed. It is usually necessary to cocainise the eye before doing this. The presence of any swelling. e.g. hordeolum or chalazion, is of course obvious on inspection and palpation of the lids. The intra-ocular pressure can be approximately determined by directing the patient to look down and by palpating the sclera through the upper lid with the index fingers of the two hands, the other fingers resting upon her forehead.

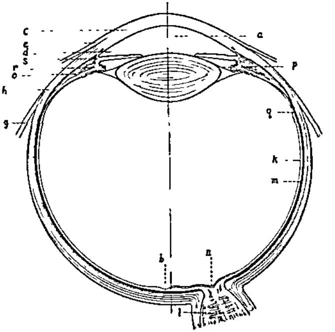


Fig 2429.—Horizontal section of eye.

(*a*) Anterior chamber.
(*b*) Fovea centralis.
(*c*) Cornea.
(*d*) Angle of anterior chamber; Schlemm's canal is just above the line.
(*e*) Conjunctiva.
(*g*) External rectus.
(*h*) Sclera.
(*k*) Retina.
(*l*) Fibres of lamina cribosa.
(*m*) Choroid.
(*n*) Optic nerve, showing physiological cup.
(*o*) Ciliary muscle.
(*p*) Suspensory ligament of lens.
(*r*) Ciliary process.
(*s*) Iris

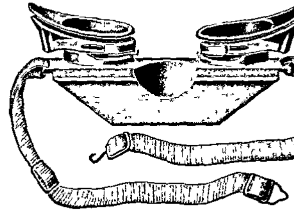
The cornea should be examined through a magnifying glass, of which the most satisfactory is the "binocular loupe" (fig. 2430), or, failing this, the monocular variety. The source of light should be placed to the side of, and slightly in front of, the patient and be focussed on to the cornea by a convex lens of 14 dioptres strength. If an electric ophthalmoscope be used, the focussing adjustment in this instrument will usually suffice to project a small bright luminous area on the cornea (fig. 2431). Daylight can be used, but usually it is more satisfactory to employ an electric lamp in the dark room. The cornea should be examined:

(*a*) For the condition of its epithelium, by instilling a drop of fluorescein and washing out with boracic lotion, when any defects will be stained green.

(*b*) For its transparency.

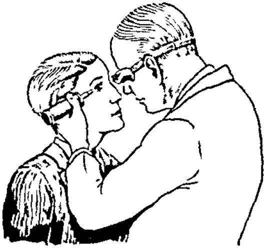
(c) For the presence of precipitates on its posterior surface or of a foreign body on its anterior surface. At the same time the aqueous should be examined for its transparency, and the presence of any exudate (hypopyon) or hæmorrhage (hyphæma) at the bottom of the anterior chamber should be noted. The iris is also examined by the method of

Fig. 2430.—BINOCULAR LOUPE.



oblique illumination, note being made of its texture, the outline of the pupil (regular or irregular), and the presence or absence of new vessels, of adhesions to the lens or cornea and of nodules and swellings. In order to make sure of the condition of the pupil, it may be necessary to employ a mydriatic, taking care to estimate the intra-ocular pressure beforehand in patients over the age of 40.

Fig 2431 —EXAMINATION WITH BINOCULAR LOUPE, USING ELECTRIC OPHTHALMOSCOPE (WITH HEAD REMOVED) AS SOURCE OF LIGHT



(2) Examination of fundus and disc is rendered much easier if an electric instead of a reflecting ophthalmoscope be used. It is well to start with a + 12 D. lens in the sight aperture and to examine the pupil reflex, directing the patient to look in various directions. By this means opacities in the lens, cornea and vitreous will become evident as dark areas in the red reflex.

The lenses should now be worked down with the finger on the driving wheel until the fundus details become clear. The disc is seen when the patient directs her eye a little upwards and nasally. If high myopia and astigmatism be present it may be difficult to obtain a clear view of the disc, and in such cases the indirect method of ophthalmoscopy must be employed. This is described in text-books of ophthalmology.

(3) *Visual acuity* is tested by asking the patient to read a series of letters on a test card placed at a distance of 6 metres and suitably illuminated. The letters are graded according to the distance at which they should be read by an eye of normal acuity, and the result of the examination is expressed as a fraction: for example, R.E. 6/12 means that at 6 metres the patient's right eye reads type which a normal eye should be able to read at 12 metres. It does not mean that the eye has only half normal vision. The estimation of errors of refraction is outside the scope of this section. but they are the commonest cause of defective vision, and until they have been excluded or corrected, the fact that a patient is unable to read 6 6 with each eye separately has little clinical value. Considerable help may often be obtained by making a pin-hole in a piece of black cardboard and directing the patient to look through this, when a definite improvement will be obtained in visual acuity if she has an error of refraction.

(4) *Visual field examination.* Quite a useful idea of the field can be obtained without the employment of a perimeter, tangent screen, etc., by the method of confrontation. A piece of white paper about half an inch in diameter is inserted between the points of a pen-nib, the handle of the pen being used as a holder. The patient stands with her back to the light and the surgeon about fourteen inches away from her. He then directs her to cover one eye, say the left, and to look straight into his left eye with her right. If the surgeon now closes his right eye he can check the patient's field against his own by bringing the object in from various directions and asking her to say when she sees it. On the temporal side, this does not hold, since the field extends to over 90 degrees from the fixation point, so the object must be brought round from a point about level with the patient's ear. A similar method may be used with coloured objects in detecting the presence or absence of a central scotoma for colours (e.g. in tobacco blindness, retrobulbar neuritis, and some cases of pituitary tumours).

DISEASES OF THE LIDS

(1) *Anomalies of development.* The lids may in rare instances be absent (ablepharia) or only partially developed, and sometimes the

unbroken skin may pass in front of the eye (cryptophthalmos) which is more or less imperfectly developed. The lids are sometimes united wholly or partially by their margins (akyloblepharon) or to the bulbar conjunctiva (symblepharon). A more common congenital defect is the presence of a cleft (coloboma) in the upper lid, and possibly in the lower lid too. It is due to defective closure of the orbito-nasal fissure, and may be associated with a dermoid of the cornea underlying the coloboma, congenital hernia of orbital fat, owing to a defect in the orbital diaphragm, and trichiasis of the lower lid. The occurrence of an epicanthal fold may cause a pseudo-convergent squint. Another fold which sometimes occurs is epitarsus, a reduplication of the conjunctiva which passes from the fornix to be inserted near the lid border.

Congenital ptosis occurs from non-development or defective development of the levator or of its nerve supply; it may be unilateral, but usually affects both sides, and is often hereditary. The patient throws her head back in order to see under the drooping lids and raises her eyebrows in an endeavour to tighten the skin of the upper lids and draw them up. There is often an associated defect of the superior rectus. The condition is amenable to operation.

(2) *Infections.* The commonest goes under the name of blepharitis; a generic term applied to the various types of sub-acute and chronic inflammations which affect the lid borders. There are two main varieties:

(*a*) *Dry blepharitis*, in which the lid margin is reddened and crusted with bran-like scales.

(*b*) *Ulcerating blepharitis*, in which on removal of crusts an ulcerating area remains. These ulcers affect mainly the area around the lash follicles, and are often associated with a chronic infection of the follicles which results in loss of the affected lashes. The lashes may regenerate later, but frequently grow inwards and rub against the cornea (trichiasis).

The causes of blepharitis are manifold and include uncorrected errors of refraction, exposure to various forms of irritation (heat, wind, dust or smoke), defective diet, unhygienic surroundings, debilitating diseases—e.g. measles—and the presence of a chronic conjunctivitis, especially trachoma.

Treatment consists in removal of the crusts by an alkaline lotion, the application of ointments such as ung. hyd. nit. $\frac{1}{10}$ B.P. strength, or one containing zinc oxide and icthyol, the prescription of glasses if necessary, and the administration of some anti-staphylococcal remedy such as manganese or tin. Some cases are due to secondary infection from the scalp and will not improve until the coexisting seborrhœa

capitis has been efficiently treated. In obstinate cases injections of a mixed streptococcal and staphylococcal vaccine into the lids has given good results, especially when combined with a complete change of environment.

Styes (hordeola) and Meibomian cysts (chalazia). A stye consists of a minute abscess, starting in the sebaceous gland of a lash follicle. It is best treated by hot bathing, the application of yellow oxide ointment and the administration of some anti-staphylococcal remedy or of pil. calx sulphurata. Cases of orbital cellulitis have occurred from too early incision into a stye, and it is usually wiser to omit any surgical interference. For the same reason a Meibomian cyst should not be opened until all acute inflammation has subsided. It may then be incised and curetted under local anæsthesia. The cyst contains granulation tissue, which accumulates as the result of chronic inflammation following obstruction of the duct of a Meibomian gland.

The conditions *entropion* and *ectropion*, as affecting the *lower lid*, apart from the cicatricial varieties, usually occur in elderly patients. Entropion is due to spasm of that part of the orbicularis known as the muscle of Riolan ; ectropion to laxity of the orbicularis and to chronic conjunctivitis. Entropion or inversion of the *upper lid* may also occur, and is usually the result of trachoma. In this disease the palpebral conjunctiva becomes scarred and contracted with resultant bending of the lid and irritation of the cornea by the lashes. Various types of plastic operation are used to rectify the condition.

(3) *New growths of the lid* include papillomata, sebaceous horns, angiomata, plexiform neuromata and neurofibromata, also malignant growths such as carcinomata and rodent ulcers. These have the same characteristics as in other parts of the body and call for no special description.

LACHRYMAL APPARATUS

Disease of the lachrymal apparatus is usually associated with an overflow of tears (epiphora) which results from excessive secretion of the gland or from defective drainage. Apart from weeping, in which the stimulus arises from the cerebral cortex, excessive secretion of tears arises as a reflex effect of stimulation of the fifth nerve. It therefore occurs when the cornea is irritated by a foreign body, smoke, the occurrence of keratitis, when the iris is irritated as in iritis, or when the nasal mucosa is irritated, e.g. coryza, or hay fever.

Defective drainage. The lachrymal drainage system consists of the puncta, the canaliculi, the sac and the naso-lachrymal duct, and obstruction to any of these will cause epiphora. Malposition of the

inferior punctum in old age occurs as a result of senile atrophy of the muscle of Riolan, and any other type of ectropion will also bring about the same epiphora. The punctum may be put out of action if a lash becomes implanted in it—an occurrence which is not very uncommon. Apart from trauma, which may sever the canaliculi, the commonest cause of their blockage is infection with streptothrix. The treatment for this is to slit up the canaliculus with Weber's knife (fig. 2432) and to scoop out the calcified contents. Obstruction of the sac is unusual, but the point where it joins the naso-lachrymal duct is the commonest site for a stricture. Anatomically there is very little difference in calibre between the sac and the duct (fig. 2433), but from the clinical standpoint the dis-

Fig 2432.—WEBER'S KNIFE, BLUNT POINTED SO AS TO AVOID INJURY TO THE MUCOUS MEMBRANE LINING OF THE CANALICULUS.

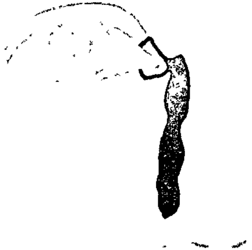


Fig 2433.—SURFACE MARKING OF THE LACHRYMAL CANALICULI, SAC AND NASO-LACHRYMAL DUCT.

tinction is useful. Once obstruction has occurred a vicious circle is established as the stagnant tears become infected and converted into muco-pus, usually pneumococcal, which irritates the cornea, thus causing increased secretion of tears. In addition, the eye is bathed constantly in a culture of pneumococci, and if any injury to the epithelium is sustained the resulting "serpiginous ulcer" may destroy the sight.

Lachrymal obstruction in the new-born is not uncommon, being due to delayed canalisation of the duct. It usually suffices to keep the sac empty by gentle digital pressure every hour or so until the duct becomes patent—a matter of about six weeks. If this fails, a fine probe should be passed, under a general anæsthetic. Lachrymal obstruction in the adult should be treated both from the eye and the nose, since it is

often infection in the latter which is the primary cause of the condition.

The patient should be given some lotion for bathing the eye, and be instructed to express the contents of the sac at least every hour during the day, and for a week or so the sac should be syringed out daily with boric lotion. If at the end of this time none passes into the nose, the sac should be filled with a solution of cocaine and adrenalin and a probe passed. This is a difficult, delicate and painful manœuvre, and usually necessitates slitting up the canaliculus first. It may have to be repeated, and if in spite of this the obstruction persists, the sac should either be excised or an anastomosis be effected between it and the nose through the floor of the lachrymal fossa by West's or Toti's operation.

The lachrymal gland is sometimes the seat of disease. Acute dacryoadenitis causes a painful swelling in the upper and outer part of the orbit, but usually yields to fomentation. New growths have also been described, the commonest being a mixed tumour of the same type as that found in the parotid gland.

CONJUNCTIVA

Injuries. Apart from the lodgment of a foreign body, the commonest injury of the conjunctiva results from the entry of some corrosive liquid. Alkalis—ammonia and caustic potash or soda—are usually more harmful than acids, but lime burns are the worst of all, because of their effect on the cornea. Immediate treatment consists in free lavage with normal saline or boracic lotion and the instillation of some lubricant such as parolene or boric vaseline. Later, after separation of the slough, a glass rod should be passed round the conjunctival sac daily to prevent the formation of adhesions between the bulbar and palpebral portions of the membrane. In the case of lime burns, drops of 10 per cent neutral ammonium tartrate or of 2 per cent cane sugar should be used two or three times daily, in the hope of dissolving the corneal opacity. Ammonium tartrate drops cause a good deal of pain, and cocaine may have to be instilled beforehand.

Subconjunctival ecchymosis is of fairly common occurrence, and may be idiopathic, traumatic, or the result of high blood-pressure. In most cases it is of no clinical significance, and the blood absorbs within ten to fourteen days. No treatment is required unless a succession of hæmorrhages occurs, when calcium gluconate and parathyroid or the administration of a serum, e g. thromboplastin, may be of service.

Chalky concretions occur fairly frequently in the palpebral con-

junctiva and the fornices. They may act as foreign bodies, and give rise to the same symptoms, when they should be pricked out by the point of a Bier's knife after cocainisation.

CONJUNCTIVITIS

This may affect only the epithelium—superficial or catarrhal—or may penetrate more deeply and affect also the connective tissue of the conjunctiva—*interstitial conjunctivitis*.

A. *Superficial Conjunctivitis* is characterised by engorgement of the conjunctival vessels, the presence of a variable amount of secretion, and a sensation of irritation or grittiness in the lids. The main varieties are:

(1) *Simple catarrhal conjunctivitis* due to non-bacterial causes, such as exposure to irritant vapours, dust, wind, excessive glare and ultra-violet light (snow blindness). The conjunctival engorgement is often only slight, and there may be little or no discharge.

(2) *Angular conjunctivitis* due to the diplobacillus of Morax and Axenfeld, an organism which feeds only on dead cells and therefore finds its pabulum at the canthi, whither the exfoliated cells are swept by the action of the lids. The characteristic feature of this form of conjunctivitis is therefore redness of the conjunctiva and the skin of the lids, being most evident at the outer and inner canthi. This is usually accompanied by considerable irritation of the lids, which is particularly marked in the evening.

(3) *Muco-purulent conjunctivitis* is an acute contagious variety, frequently epidemic and due to the Koch-Weeks bacillus, an organism which closely resembles Pfeiffer's influenza bacillus. The disease is characterised by the occurrence of a muco-purulent secretion and of subconjunctival hæmorrhages.

(4) *Chronic catarrhal conjunctivitis* may be the outcome of any of the above, if inefficiently treated. It is frequently associated with ectropion due to cicatricial contraction of the skin of the lids induced by their chronic irritation from epiphora. In these cases a plastic operation is usually required to restore the lids to their proper position.

Chronic monocular conjunctivitis is commonly due to one of the following causes:

(*a*) A foreign body in the conjunctival sac or on the cornea.

(*b*) Misplaced lash or lashes.

(*c*) Chronic dacryo-cystitis.

(5) *Purulent conjunctivitis* includes:

(*a*) Ophthalmia neonatorum, due in 60 per cent of cases to

gonococcal infection, usually at the time of birth, and in the remaining 40 per cent of cases to other organisms such as streptococci, staphylococci, B. coli and pneumococci.

Three stages are recognised: serous infiltration lasting a few days, in which the conjunctiva of the lids is swollen, tense and shiny; pyorrhœa, lasting 2 to 6 weeks, in which there is a very free flow of pus from the conjunctival sac: and chronic blenorrhœa, in which a chronic thickening and infiltration of the lids and conjunctiva is present.

The most serious complication is the occurrence of corneal ulcers which, on healing, leave dense opaque scars. In some cases they perforate with consequent infection of the interior of the eye, and the formation of anterior polar cataracts or of unsightly bulging scars which often contain prolapsed iris tissue (staphylomata).

(*b*) Purulent conjunctivitis of adults is a more serious condition, and fairly frequently results in loss of the eye owing to the violence of the inflammation.

(*c*) Membranous conjunctivitis. In this condition the exudate coagulates, forming a membrane. In the diphtheritic form of the disease —due to the Klebs-Loeffler bacillus, this membrane can only be separated with difficulty from the underlying conjunctiva, and leaves bleeding points. In the croupous form the membrane peels off more easily. Both these types can be produced by streptococcal infection.

Treatment of catarrhal conjunctivitis consists in:

(1) Keeping the eye as free as possible from discharge by bathing it three or more times a day with boracic lotion, to which may be added liq. hamm. dist. (B.P.) (1 drachm to the ounce). In angular conjunctivitis a lotion of boric acid and zinc sulphate ($\frac{1}{2}$ gr. to the ounce) is employed.

(2) The application of some bland unirritating ointment to the edges of the lids at night, e.g. ung. acid boric, in order to prevent the lids adhering.

(3) The use of some silver preparation. In acute cases, silver nitrate, 1 to 2 per cent, should be applied once daily to the conjunctival surface of the everted lids on a piece of cotton wool wrapped round a glass rod. In less acute cases, one of the organic preparations of silver, e.g. argyrol 10 per cent, should be used in the form of drops three times daily.

It is important not to cover the eye with a shade as this leads to accumulation of the secretion. Cocaine also should be avoided as it has a deleterious effect on the corneal epithelium. The patient should not be allowed to wipe her eyes with a handkerchief, but should use small pledgets of cotton wool which can be burnt after use, and she

should periodically boil any droppers, eye-cups or undines which are used. The possibility of an uncorrected error of refraction should be borne in mind in cases of chronic catarrhal conjunctivitis.

B. *Interstitial Conjunctivitis*. In this, the connective tissue layers of the conjunctiva are also involved. It comprises the following:

(1) *Trachoma*, a contagious disease associated with the formation of follicles, of a gelatinous character, in the fornices and in the tarsal conjunctiva, and with the development of "pannus." The latter consists in new vessels growing down into the cornea from its upper conjunctival margin.

Trachoma is a disease of long duration and even under the best conditions the average time required for treatment is 18 months. The cause is not yet known. Noguchi found an organism, B. granulosis,

Fig 2434.—Tyrell's forceps for expressing trachomatous follicles in fornices of the conjunctiva.

which he thought was the cause of the disease, but the matter is still *sub judice*. The dangers of trachoma lie in its sequelæ, which comprise:

(*a*) Blepharitis, often followed by trichiasis which causes ulceration of the cornea.

(*b*) Entropion of the upper lid due to cicatricial contraction of the palpebral conjunctiva, symblepharon due to the same cause, and xerosis due to obliteration of the ducts of the main and accessory lachrymal glands. In this condition the cornea becomes dry and opaque.

(*c*) Corneal opacities, due to cicatrisation of the area affected by pannus and to healing of corneal ulcers.

Treatment. In the early stages the follicles must be expressed with Tyrell's forceps (fig. 2434) after free cocainisation, or in children under a general anæsthetic, a glycerine solution of hyd. perchlor. 1 in 100 being rubbed into the conjunctiva afterwards. When the follicles lie in the tarsal conjunctiva, they are better dealt with by scarification with a Bier knife and subsequent expression

In the later stages, daily application of a copper sulphate stick is made to the everted lids, combined with the use of a boracic and zinc sulphate lotion.

Entropion is dealt with by a plastic operation, and trichiasis by epilation of the misplaced lashes or by electrolysis.

(2) *Spring catarrh* is also characterised by the formation of granulations in the conjunctiva. Two types are described: limbal in which the swellings occur at the corneo-scleral junction, and palpebral in which they are found in the lids. The disease is seasonal and tends to become less severe with increasing age. It is probably allergic in origin. Diagnosis is usually easy, since the conjunctiva is covered by a thin milky film which microscopically is found to contain large numbers of eosinophils.

Treatment is of little avail, though good results are sometimes claimed from the use of radium. The intolerable itching which is a feature of the disease may be relieved by acetic acid lotion (acid acetic dil., ½ drachm to the ounce) or carbolic lotion (acid carbolic 2½ grs. to the ounce). The wearing of tinted goggles with side-pieces is sometimes of service in preventing access of the unknown antigenic substance to the eyes.

(3) *Follicular conjunctivitis.* Minute pale follicles can be found in the lower fornix in about 50 per cent of otherwise normal children. The condition is one of lymphoid hypertrophy, akin to "adenoids," and usually disappears in adolescence. Such children are more liable to catarrhal conjunctivitis, and when this occurs it is treated on the usual lines, special attention being paid to correction of errors of refraction.

(4) *Tuberculous conjunctivitis* may be associated with lupus of the lid or may occur as a primary infection. Two types are described: (*a*) ulcerative, in which the floor of the ulcer is covered with greyish-red granulations, and (*b*) proliferative, in which a cock's comb-like mass of exuberant granulations is formed. The granulations should be excised or curetted and the general treatment for tuberculosis instituted.

NEW GROWTHS AND CYSTS OF THE CONJUNCTIVA

A. *Benign.* These include dermoids which are found at the corneo-scleral margin, and pigmented nævi which usually occur in this region too. The latter may develop into melanotic sarcomata.

B. *Malignant.* These are also at the limbus and may be sarcomatous —usually pigmented—or carcinomatous, when they are pale pink or greyish-white in colour.

Treatment. If the growth is under 5 mm. in diameter, local removal and subsequent application of radium will suffice. If larger, the eyeball and conjunctiva should be removed, together with the affected glands (pre-auricular and submaxillary) if enlarged.

C. *Degenerations.* *Pinguecula* is a yellowish thickening due to hyaline degeneration of the bulbar conjunctiva. Its commonest

situation is adjoining the nasal side of the *limbus*. It does not usually develop until middle age.

Pterygium follows prolonged exposure to hot dry wind and is common in Australia and South Africa. A wing-shaped fold of conjunctiva grows slowly over the cornea, usually from its nasal margin. Treatment is by operation.

CORNEA

A. *Anomalies of Development.* The central portion of the cornea may be more curved in one meridian than in the other, a condition which results in the production of astigmatism, or it may be so thin and weak that it gradually bulges forward to produce the condition known as conical cornea. Though the weakness is probably congenital, the formation of the cone is often delayed till after puberty. It causes great reduction of visual acuity and is usually binocular.

B. *Inflammation.* Keratitis may occur with or without ulceration. In the former case the cause is generally local; in the latter it is blood-borne.

(1) *Ulcerative Keratitis.* There are many forms of corneal ulcer and the majority of them cause the following *symptoms:*

(*a*) Photophobia (fear of light).

(*b*) Pain.

(*c*) Lachrymation.

(*d*) Blepharospasm, i.e. spasmodic closure of the lids.

(*e*) Impairment of vision.

When the ulcer is a deep one, however, symptoms (*a*)-(*d*) may be quite inconspicuous owing to the fact that the surface of the cornea is the part most richly supplied with sensory nerves. The *signs* of corneal ulceration comprise:

(*a*) Circumcorneal (or ciliary) injection.

(*b*) The presence of some degree of opacity—not always evident when the ulcer affects only the epithelium.

(*c*) Irregularity in the surface of the cornea, best seen by deformation of the reflection formed by the cornea of a window (method of specular reflection).

(*d*) Development of new vessels in the cornea—a fairly late occurrence.

(*e*) The occurrence of green staining after instillation of a drop of fluorescein solution and subsequent washing out with boric acid lotion.

(*f*) In some cases, signs of accompanying conjunctivitis, iritis or cyclitis.

The common *types* of corneal ulcer are as follows:

(*a*) *Phlyctenular.* Usually seen in children who have been brought up in unhygienic surroundings. The disease begins with the development of one or more small solid elevations at the limbus, accompanied by local dilatation of the vessels. These may absorb and leave no trace of their presence, or may break down and ulcerate forming a crescentic marginal ulcer or one which slowly advances towards the centre of the cornea, leaving a trail of vessels behind it (vascular fasciculus).

Apart from the limbal form, there is also a primary phlyctenular keratitis in which sub-epithelial infiltrates develop in the cornea with resulting ulceration of varying severity. The scars left from this are often responsible for marked impairment of vision.

Phlyctenular disease is primarily allergic in nature and in a fair number of cases is associated with the presence in the blood of tuberculo-protein. In other cases it seems to be due to absorption of toxins from an infected scalp or from infected tonsils and adenoids, while in a third group of cases it is dependent on digestive disturbances and chronic constipation. Treatment is therefore primarily hygienic in character. Locally, the regular use of a simple boracic lotion and of yellow oxide ointment is of service. If there is much corneal involvement, atropine base 1 per cent should be added to the ointment, and dark glasses worn.

(*b*) *Ulceration secondary to conjunctivitis.* The commonest type is a crescentic ulcer at the margin of the cornea which is of little pathological importance and heals rapidly when the conjunctivitis is cured. In other cases minute infiltrates develop in the substance of the cornea near the limbus, and these frequently absorb leaving no trace of their presence. In gonococcal conjunctivitis the ulceration may be more severe and result in perforation of the cornea.

(*c*) *Serpiginous ulcer.* This is most commonly found in the elderly and in association with chronic dacryo-cystitis. In such a condition the cornea is being constantly bathed in an almost pure culture of pneumococci, and the slightest abrasion of its epithelium allows these organisms access to the substantia propria, with resulting disintegration. The pneumococcal toxin has a predilection for diffusing through the cornea so that it exerts a chemotactic effect on the iris with resulting effusion of lymph and leucocytes into the anterior chamber. The sterile pus thus formed collects at the bottom and constitutes an "hypopyon."

Treatment. In addition to the ordinary local treatment the presence or absence of dacryo-cystitis should be established, and if found, the infected sac should be removed. The patient should be put on

to a mixture containing hexamine, and a lotion or drops of magnesium sulphate (half saturated solution) should be employed.

(*d*) *Epithelial ulcers.* These, at any rate in their early stages, affect only the epithelium, and comprise:

(i) *Superficial punctate keratitis*, which may occur in epidemic or sporadic form and consists in the development of numbers of minute areas which stain green with fluorescein. In the early stages there is some associated conjunctivitis with photophobia and circumcorneal injection due to the keratitis. The disease is probably due to the action of some undetermined virus and is frequently associated with naso-pharyngeal catarrh. It clears up under local treatment in a period of six weeks or longer, some cases lasting several months.

(ii) *Dendritic ulcer* is very apt to be overlooked and diagnosed as conjunctivitis unless fluorescein is used as a routine in the examination of all "red eyes." The ulcer then appears as a fine wavy green line with dendritic branches. It is due to infection of the corneal epithelium with the virus of herpes febrilis.

(iii) *Neuropathic keratitis* occurs in connection with ophthalmic herpes zoster, particularly when vesicles have developed on the side of the nose, indicating involvement of the naso-ciliary nerve. In the early stages, small discrete or larger confluent spots may develop on the surface of the cornea.

(iv) *Neuroparalytic keratitis* is due to anæsthesia of the cornea and is therefore liable to develop after operations for relief of trigeminal neuralgia, e.g. alcohol injection of the Gasserian ganglion. In the earliest stages there is a haziness of the corneal epithelium which soon gives place to ulceration. The only treatment which holds out any prospect of success is to unite the middle two-thirds of the upper and lower lids.

(2) *Non-Ulcerative Keratitis* occurs in three forms:

(*a*) *Interstitial keratitis*, due to congenital, and very occasionally to acquired, syphilis. It occurs between the ages of 5 and 15 and frequently develops in the second eye, even though the patient is already under treatment for the first eye. The onset may be associated with some slight local trauma and there are usually stigmata of congenital syphilis.

Early signs comprise pain, photophobia, corneal haze (ground glass cornea) and circumcorneal injection. New vessels soon develop, the majority of which are deep in the substance of the cornea. They appear to start at the limbus, have no conjunctival continuation, and are associated with opacity in the middle and posterior layers of the substantia propria. Associated with the keratitis are iritis, cyclitis and

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anterior choroiditis. The acute stage lasts usually for several months, after which the cornea begins to clear from the periphery. The amount of permanent opacity varies considerably, but in most cases, if efficient treatment is instituted, serviceable vision will remain. It is not uncommon for myopia to develop after an attack of interstitial keratitis. Treatment comprises the usual local measures and prolonged anti-syphilitic treatment.

(b) *Tuberculous keratitis* is rather similar to interstitial keratitis, but usually involves only part of the cornea. There are often large deposits of inflammatory cells on the back of the cornea ("mutton fat K.P.") and areas of scleritis adjacent to the corneal infiltrates.

(c) *Keratitis profunda.* In this an opacity, often circular, develops in the deeper layers of the cornea, usually in the central area. There is attendant circumcorneal injection and new vessels may or may not develop. Some of the cases are undoubtedly tuberculous in origin, while others are due to focal sepsis, particularly in the nose and teeth. The condition may follow trauma. In addition to local treatment, the underlying cause must be dealt with.

Local treatment of keratitis comprises the use of a pad and bandage, atropine and the local application of heat, either by an electrically warmed pad or by "hot bathing." For the latter, the patient is given a wooden spoon with cotton wool tied round the bowl and a pot of hot boric lotion (boric acid, 1 drachm to the pint). She bends her head forward, dips the bowl end of the spoon in the lotion and then holds it against her closed eye as hot as she can bear it. When it cools a little, she takes another dip and continues the process for a quarter of an hour, and then covers the eye with a pad of dry wool. Hot bathing is usually performed three times daily. Carbolising is often of great assistance in bringing about rapid healing of an ulcer, particularly when it is of the dendritic type. The cornea is cocainised and the ulcerated area carefully dried with small pieces of blotting-paper. A pointed match-stick is then dipped in pure liquid carbolic and applied to the ulcer, any excess being carefully dried off with the blotting-paper. The eye is gently irrigated with some boric lotion and the lids allowed to close. The more severe types of ulcer demand the use of the actual cautery or the performance of Saemisch's section, procedures which are best left to the ophthalmologist.

Corneal degenerations. The majority of these are rare. It should be noted, though, that various calcareous and pigmentary changes may occur at the sites of old scars, and as the aftermath of chronic inflammatory processes such as irido-cyclitis, particularly when associated

with secondary glaucoma. Any portion of the cornea which is not covered when the lids are closed tends to become dry and ulcerated, e.g. in proptosis from orbital tumours or from extreme degrees of Graves' disease.

New growths of the cornea are rare and comprise dermoids, sarcomata and carcinomata. They usually arise at the limbus.

IRIS AND CILIARY BODY

Congenital anomalies. Various defects in the development of these structures may occur, from aniridia (apparent absence of the iris) to coloboma iridis, in which a portion of the iris is absent, owing usually to some fault in closure of the fœtal cleft. This is generally associated with a notch in the edge of the lens and a gap or coloboma in the choroid.

Aberrations in pigmentation, if in the direction of excess, cause the development of melanomata and, if in the direction of deficiency, cause various grades of albinism, which may occur in one eye only (heterochromia iridis). Remnants of the fœtal pupillary membrane sometimes persist in the form of a few tags passing from the circulus iridis minor to the anterior capsule of the lens.

Iritis and iridocyclitis may be acute or chronic and due to many causes. In a recent review of 118 cases the following figures were quoted:

22·0 per cent were of tonsillar origin.
16·9 ,, ,, ,, of syphilitic origin.
12·7 ,, ,, ,, due to infected teeth.
8·5 ,, ,, ,, due to combined infections.
6·8 ,, ,, ,, due to sinusitis.
6·8 ,, ,, ,, due to gonorrhœa, 5·1 per cent being due to prostatic infection, 1·7 per cent to pelvic infection—women.
1·7 ,, ,, ,, diabetic; while in
16·1 ,, ,, no cause was found.

These serve to show the diversity of infections which may by metastasis or toxæmia cause iritis or iridocyclitis, the position being still further complicated by the view widely held on the Continent that many cases are due to an allergic reaction of the iris and ciliary body to the presence in the blood of tuberculo-protein. Also there are the cases due to direct infection by perforation of the globe owing to trauma, which are not included in this table.

The *symptoms* comprise:

(1) Pain, usually circumorbital and in the distribution of the ophthalmic division of the 5th nerve.

(2) Dimness of vision.

(3) Photophobia and lachrymation.

(4) Sometimes general malaise.

The *signs* are :

(1) Ciliary or circumcorneal injection, in which the redness is most marked near the cornea and fades away towards the fornices of the conjunctiva.

(2) Contraction of the pupil, due to reflex irritation of the sphincter and to increased bulk of the iris consequent on its vascular and lymphatic engorgement.

(3) The formation of adhesions between the iris and underlying lens capsule. These may be broad or narrow, their presence causing irregularity in the pupil margin, which is particularly evident after the use of a mydriatic.

(4) Blurring of the pattern of the iris (due to its œdema) and alteration in colour—a blue iris becoming greenish, and a brown one greyish or yellowish in colour.

(5) The exudation of leucocytes and sometimes of blood varies according to the severity of the disease, from a slight haze barely visible except with the corneal microscope to the formation of definite pus, which is usually sterile, lying at the bottom of the anterior chamber and called hypopyon. In very acute iritis, particularly gonococcal, the aqueous becomes gelatinous owing to its increased protein content. The same condition may also be responsible for some increase of intra-ocular pressure (secondary glaucoma) and the development of myopia.

(6) Haze of the cornea, due to œdema of the substantia propria and the deposition of inflammatory products on its posterior lining endothelium. These, when well marked, form discrete dots, called keratic precipitates or K.P. Their presence usually indicates involvement of the ciliary body in the inflammatory process.

(7) When the ciliary body is markedly involved, inflammatory products pass out from it into the vitreous, forming opacities in this medium, and if the condition lasts for long some of the lens fibres may be poisoned by the toxins with resulting " secondary cataract." The lens may also have an opaque membrane in front of it, in the pupillary area, due to exudation from the iris.

Course of iritis and iridocyclitis. All grades of inflammation occur, as well as great variations in the duration of the condition. In the acute cases all the signs and symptoms already detailed may be seen, whereas in a mild case of chronic cyclitis the patient may complain of mistiness of vision, and examination reveal merely a few spots of K.P., a little iris discolouration and some opacities in the vitreous.

Complications. The occurrence of mild secondary glaucoma from increased viscosity of the aqueous has already been mentioned. Glaucoma may, however, occur in another way ; if the iris becomes adherent to the lens capsule all round the pupil margin, the aqueous which is formed

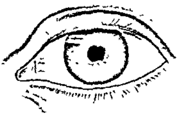

Fig. 2435.—Iritis before instillation of a mydriatic, pupil appears almost regular in outline

from the ciliary body cannot pass forwards through the pupil and escape through the canal of Schlemm, and thus the intra-ocular pressure increases.

If the adhesion be limited to the pupil margin, the rest of the iris will be ballooned forward by the imprisoned aqueous causing the condition known as *iris bombé* (see fig. 2437). In some cases, however (e.g. total annular synechia), the peripheral portion of the iris is also adherent to the lens capsule, so that it cannot bulge forwards.

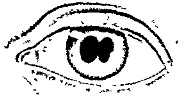

Fig. 2436.—Iritis after instillation of a mydriatic, showing irregularity of pupil margin due to adhesions at 12 o'clock, 3 o'clock and 6 o'clock.

In cases where exudation has occurred into the vitreous it may organise into fibrous tissue and form an opaque plaque behind the lens. Contraction of this tissue may result in detachment of the retina, shrinkage of the eye as a whole (phthisis bulbi) and total blindness.

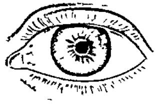

Fig 2437.—Iris bombé. The iris being adherent to the lens capsule all around, the pupil margin is bulged forwards by the aqueous accumulated behind it.

Treatment of Iridocyclitis.

General. The patient should be carefully examined for any of the lesions or diseases already mentioned and suitable treatment instituted. In syphilitic cases, treatment must not be too vigorous in the early stages or a Herxheimer reaction will be produced which makes matters worse. It must also be continued for a long enough time to avoid "rezidiv" reactions after its cessation. In gonococcal cases, the use of a vaccine is often of the greatest service, but here again its use must be continued for a long time (6 to 12 months) after cessation of the iritis or a relapse will occur. Many patients with acute iritis are definitely ill, and are better kept in bed for a week or longer on a light diet. During this time excretion should be stimulated by aperients, the use of hot-air baths, and the drinking of large quantities of bland fluids. Internal salicylate medication is often of great service, particularly in cases of undetermined origin, or, if this fails, resort may be had to hexamine which is said to be excreted into the aqueous. In cases which do not improve in spite of treatment, various other measures may be employed. Of these the most useful are: (1) The administration of a series of 4 to 6 injections of salvarsan or of N.A.B., which often brings about marked improvement even in non-syphilitic patients. (2) Protein shock therapy. The simplest method of employing this is to give a series of 6 injections of 10 cc. of sterilised milk into the buttock. Pyrexia and leucocytosis follow, and a second injection should not be given until the temperature has remained normal for 24 hours. (3) Prolonged administration of tuberculin, starting with very small doses, e.g. a millionth of a milligramme of B.E.

Local. Atropine is used in order to set the iris at rest. If there is much lachrymation it is best employed in the form of ointment (1 to 2 per cent), and if much injection, previous instillation of adrenalin drops

may be necessary. In acute cases the eye is covered with a pad and bandage, and heat applied to it either by hot bathing (see page 4534), by an electrically warmed pad, or by diathermy. Two leeches applied to the temple are often of service in the relief of pain and diminution of congestion, and are especially valuable in cases with increased intra-ocular pressure. *Iris bombé* demands the performance of an iridectomy, an operation which may also be successfully employed in cases of recurrent attacks of iritis.

Cysts and new growths of the iris are of rare occurrence and need not be mentioned here. Traumatic lesions are described in the section dealing with injuries.

PANOPHTHALMITIS

The eye may be grossly infected with pyogenic organisms, either by the blood stream as in pyæmia, especially the puerperal form, or by infection from without, as in perforating ulcers, injuries and operations. In the virulent forms of infection the whole eyeball is affected. The cornea is hazy, the aqueous turbid, the pupil filled with exudate, and the lids swollen. Severe pain is felt, with chills, nausea and vomiting, and as the inflammation spreads to Tenon's capsule, proptosis develops. Eventually the eye ruptures, either through the sclera or the cornea, the pus escapes and the pain subsides, the ball in about six weeks becoming soft, sightless and shrunken. In less virulent infections the process may be localised to the aqueous chamber or to the vitreous, but the end-result is frequently a blind, useless eye. Sympathetic disease of the fellow eye is fortunately not met with in cases of suppurative ophthalmitis, so that simple evisceration of the affected eye may be performed, while if the surrounding orbital tissues also are involved an incision into them may be necessary. If the infection is still limited to the eyeball, however, enucleation is probably the best procedure.

THE LENS

Apart from traumatic conditions, cataract is the only change in the lens which calls for notice. Numerous varieties of lens opacity have been described, of which the following are the most important:

(1) *Congenital and Infantile.* (*a*) Punctate, in which there are numerous " milk dots " in the lens substance, especially near the periphery. The condition is due to defective development of portions of lens fibres, whereby they are opaque instead of transparent. It usually remains the same throughout life, and is of no pathological significance.

(*b*) Lamellar, zonular, or peri-nuclear. In this, the defect has been more extensive, and one or more complete layers of lens matter are

elderly people to dispense with reading glasses (so-called "second-sight").

THE CHOROID

Congenital Anomalies.

(1) Coloboma of the choroid. In this the choroid, usually in the region of the fœtal ocular cleft, does not develop. The sclera is thus left bare, and appears with the ophthalmoscope as a large white patch, usually below the disc. In rare cases the whole choroid is absent (choroidoremia).

(2) Melanomata appear as black or brown masses of varying size. They should be watched, particularly after middle age, in case malignant change supervenes.

(3) Albinism is associated with absence of choroidal pigment and of the retinal pigment layer. The choroidal vessels are therefore conspicuous.

CHOROIDITIS

Being anatomically continuous with the iris and ciliary body the choroid is liable to infection from the same sources (see page 4535), though the percentage incidence is not quite the same, the commonest invading organism being the spirochæte.

Choroiditis, if it lasts for any length of time, nearly always involves the overlying retina, producing the condition known as choroido-retinitis. It occurs in various forms, the two main groups being acute suppurative (see Panophthalmitis, page 4539), and sub-acute or chronic. In the latter the lesion, or lesions if localised, may be central (i.e. near the posterior pole of the eye) or peripheral, or they may be disseminated, i.e. spread widely over the fundus. Choroiditis is therefore divided into the following types:

(1) Disseminated, in which small areas are formed all over the fundus.

(2) Diffuse, where there are large areas of exudate with ill-defined margins.

(3) Juxta-pupillaris, where the focus of inflammation is adjacent to the disc margin.

(4) Anterior, where the foci are in front of the equator of the eye.

(5) Central, which includes a variety of conditions not really due to choroiditis at all, e.g. the development of hyaline thickenings in the membrane of Bruch—the so-called Tay's choroiditis, and the atrophic changes occurring as a result of myopia. Apart from these, however, fine pigmentary changes do occur in the macular region of the choroid as a result of focal infection in the old and middle-aged and cause

opaque. It is usually associated with horizontal ridges in the permanent teeth, due to a defect in development of the enamel organ, and with a history of fits in infancy.

(c) Capsular cataracts which may be anterior or posterior, the latter due to persistent remnants of the central hyaloid artery, the former to remnants of the pupillary membrane or to the perforation of a corneal ulcer in infancy.

(2) *Senile.* These are rare before the age of 50, and are bilateral, but usually affect one eye more than the other. The opacity may begin in various ways, of which the commonest are the development of radial striæ in the peripheral lens cortex and the presence of dots and vacuoles in the pupillary area of the lens. The opacity gradually increases until the whole lens becomes opaque and milky white.

Black cataract is of rarer occurrence, and has a different pathology, being due to excessive sclerosis of the lens with development of a brownish pigmentation owing to oxidation of its tyrosin.

(3) *Diabetic* cataract is indistinguishable clinically from the senile form, and for this reason all cases of cataract should be examined for glycosuria

(4) *Complicated* cataract is seen in association with prolonged iridocyclitis, choroiditis and glaucoma, and in some cases of high myopia and of retinal detachment.

The opacity commonly begins near the posterior pole of the lens.

Treatment of Cataract. The majority of cases require operation, but this should not be performed until the vision of the better eye is 6/24 or less. In lamellar and other forms of central cataract, vision may be materially improved by dilatation of the pupil. In such cases atropine drops may be ordered after a preliminary trial with homatropine, but the patient should be watched in case glaucoma supervenes.

With modern methods it is not necessary to wait for maturity of the cataract before operating. The pupil, however, should react to light and the patient should be able to tell the direction of a light shone into the eye when its fellow is covered.

Many cases of cataract do not become perceptibly worse over a period of many years, and the presence of a few peripheral striæ in the lenses of patients over the age of 70 is so common as to be almost physiological. For this reason it is unwise to tell a patient that she has cataract unless it is producing material depreciation of vision.

Common early signs of the disease are monocular diplopia or polyopia and the development of myopia. The latter will often enable

elderly people to dispense with reading glasses (so-called "second-sight").

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considerable impairment of vision, while a similar lesion may occur in syphilis.

If one looks on choroiditis from the ætiological aspect:

(1) Syphilis may cause a variety of lesions, but the commonest is the disseminated type in the acquired disease and a widespread diffuse choroido-retinitis in the inherited form. This bears a close resemblance to pigmentary degeneration. After an attack of interstitial keratitis it is not uncommon to find large masses of pigment in the anterior part of the choroid.

(2) Focal infection usually produces large solitary patches of choroiditis, sometimes of the juxta-pupillaris type, particularly when

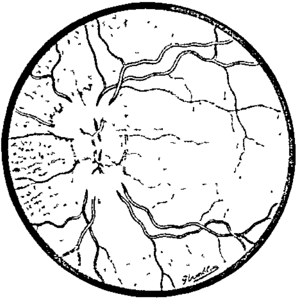

Fig 2433.—Opaque or medullated nerve fibres.

the source of the infection is tonsillar. Infection from the teeth and from the colon is a fairly frequent cause of choroiditis in the macular region.

(3) Tuberculosis, as in other parts of the body, may produce miliary or conglomerate lesions. The former are seen in the terminal stages of tuberculous meningitis, while the latter may assume large dimensions and protrude forwards into the vitreous simulating a neoplasm. According to Continental observers, disseminated choroido-retinitis is more commonly tuberculous than is usually suspected.

Symptoms of Choroiditis. Pain is absent, and the patient may complain of nothing but defective vision, and may not even notice this if the lesions are peripheral. In other cases, irritation of the retina overlying the focus of inflammation causes the appearance of flashes of light,

and displacement of the retina, with an apparent distortion of objects (metamorphopsia). Floating spots are frequently seen, due to the formation of opacities in the vitreous.

Signs of Choroiditis. The whole fundus may be veiled and indistinct owing to the presence of exudation in the vitreous. With a + 12 lens in the ophthalmoscope, dots forming a fine haze may be visible or larger individual opacities may be seen. The patch of choroiditis itself appears yellowish in the early stages, and has an ill-defined margin; a retinal vessel, if it happens to pass over the patch, can often be seen to be pushed forward by the underlying swollen choroid. In the later stages cicatrisation occurs with resultant fibrosis and obliteration of choroidal vessels. The patch therefore appears a brilliant white, with possibly a few of the larger choroidal vessels coursing over it (fig. 2438). It is bordered by pigment, since the retinal pigment in these cases acts as a foreign body, and is carried to the edges of the patch of inflammation by phagocytic cells.

NEOPLASMS OF THE CHOROID

(1) *Melanoma* appears ophthalmoscopically as an oval dark patch with a well-defined margin, and does not increase in size. It is non-malignant.

(2) *Sarcoma.* This is an intensely malignant neoplasm. It contains a varying amount of pigment, and has a strong tendency to dissemination by the blood stream, with the production of metastatic growths most frequently in the liver. Direct extension to the orbit, brain or meninges may occur, but is less common. Metastasis via the blood stream may take place before there is any visible perforation of the eye by the growth. The importance of early removal is therefore evident, but, in spite of this, metastasis is avoided in only about 50 per cent of cases.

The tumour most frequently develops between the ages of 50 and 60, though cases as young as 14 have been recorded. It begins as a flat localised swelling of the choroid, which develops most commonly in the posterior portion of this membrane. It soon becomes more spherical, and frequently penetrates Bruch's membrane, assuming a mushroom shape.

Signs and Symptoms are grouped into four stages:

(1) *The quiet period.* The patient may complain of defective vision with metamorphopsia owing to deformation of the retina. On examination with the ophthalmoscope, a portion of retina is observed to be pushed forward and beneath it, and a brownish mass may be seen covered by irregular choroidal vessels. In a fair proportion of cases large areas of retina become detached by serous exudation from the choroid, due

to the growth causing vascular engorgement. Diagnosis at this period is all important, but may be very difficult.

(2) *The glaucomatous period.* The symptoms of acute glaucoma supervene (see page 4549), and ophthalmoscopic examination is impossible through the hazy cornea. For diagnosis reliance must be placed on the history. If blindness occurred before the onset of the glaucomatous symptoms there is a strong suspicion of a growth being present. In a recent survey of cases of acute glaucoma it was found that no less than 10 per cent were due to sarcoma of the choroid. This possibility should therefore be borne in mind in all cases of acute glaucoma.

(3) *The extra-ocular period.* In this the sclera ruptures or permeation occurs along the walls of the blood-vessels penetrating the sclera.

(4) *The period of metastasis* This need not be delayed until late, as has already been mentioned. Since these growths contain numerous blood spaces formed by a single layer of endothelium, it is not surprising that emboli of malignant cells can pass from them into the general circulation.

Treatment consists in excision of the eye.

THE RETINA

Retinitis.

The majority of retinal diseases are of medical rather than of surgical interest, and are therefore not described here. The retina, as explained on page 4541, is usually involved in cases of choroiditis, but a pure retinitis can occur in some cases of syphilis in which yellowish white spots develop with dust-like vitreous opacities and degenerative changes in the blood-vessels.

In the diffuse type of choroido-retinitis which occurs in some cases of congenital syphilis the retinal changes are mainly degenerative. The pigment becomes broken up, forms masses shaped like bone-corpuscles, and sometimes mantles the veins. The retina shows small white areas ("pepper and salt" retina), the fundus reflex as a whole becomes yellowish, the vessels contract, and the disc becomes a waxy yellowish-white.

Detachment of the Retina.

Except at the disc and ora serrata, the retina merely lies in contact with the pigment epithelium, and has no attachment at all. Anything which causes a hole in the retina may therefore lead to its detachment by allowing the vitreous to herniate through and occupy the sub-retinal space.

Detachment is thus commonest in myopes, in whom the retina is under tension. It frequently occurs as the result of a blow, but in some cases there is no history of previous trauma, and in these cases the hole is often in the periphery, and is due to rupture of one of the retinal cysts which frequently develop there.

Shrinkage of the vitreous in old iridocyclitis also brings about retinal detachment, but the condition is of little surgical importance since the eye is already blind. It may also follow the operation of "needling," particularly when this is done for removal of the lens in cases of high myopia.

Retinal detachment can be brought about in another way, namely, by exudation of fluid into the sub-retinal space. Such a condition occurs in severe nephritis, particularly when due to pregnancy, and in cases where there is hæmorrhage between the retina and choroid. A sarcoma of the choroid will, of course, push the retina forward and cause an apparent detachment, to be followed perhaps by a real one.

With the ophthalmoscope the vessels on the detached portion of retina appear almost black, and are visible with a higher convex lens than the rest of the fundus. The vessels have a wavy outline, owing to the presence of folds in the retina, while the membrane itself may be an opaque white, though in early cases it is often transparent. When the patient moves her eye the retina is seen to float about. On careful examination a hole can often be seen, showing a redder reflex than its surroundings. If the field of vision be examined, an area of blindness will be found corresponding with the site of the retinal detachment. The diagnosis of a simple (i.e. serous) detachment from a malignant detachment (i.e. due to sarcoma of the choroid) may be very difficult. Points in favour of a simple detachment are:

(1) The presence of vitreous opacities.
(2) The retina floating about on movement of the eye.
(3) The presence of a hole.
(4) Lowering of intra-ocular pressure.

Treatment is by operation which aims at sealing the hole in the retina and allowing the escape of the sub-retinal fluid (cure may now be obtained in something like 50 per cent of cases).

New Growths.

The most important new growth is the so-called *glioma*, more accurately termed neuro-epithelioma retinæ. This is a highly malignant tumour developing during infancy, usually before the age of three years. It may affect only one eye, but is bilateral in 20 per cent of cases.

The earliest sign is the appearance of a white reflex in the baby's pupil, due to the vitreous being filled with growth. This can be examined with the ophthalmoscope, when it is often found to have hæmorrhages on its surface, and if the growth develops from the outer surface of the retina ("glioma exophytum") the retinal vessels may be seen.

Diagnosis has to be made from pseudo-glioma, i.e. a non-malignant mass of fibrous tissue of inflammatory or congenital origin, behind the lens. In the second stage the eye becomes painful owing to the development of secondary glaucoma, and the child is constantly crying.

In the third stage extra-ocular extension occurs along the optic nerve and at the limbus, while in the fourth stage metastatic extension occurs in the brain and skull bones.

In contra-distinction to sarcoma of the choroid, distant metastases are rare.

Treatment is by removal of the eyeball. If histological examination shows extra-ocular extension, the whole orbit should be exenterated and radium applied subsequently.

In bilateral cases, in order to avoid removal of both eyes, the eye with the smaller growth may be treated with radium. The most satisfactory method is probably the implantation of radon seeds through the sclera into the growth.

OPTIC NERVE

Various congenital malformations may occur, of which the most important is medullation of the intra-ocular nerve fibres ("opaque nerve fibres"). This produces a striking appearance with the ophthal-

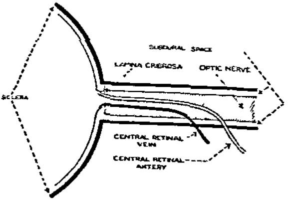

Fig 2439.—Diagram to show central retinal vessels in optic nerve.

moscope (see fig. 2438), and may cause a mistaken diagnosis of an inflammatory condition. The affected area is usually at the margin of the disc, is dense white, has a feathery edge, and partially obscures the vessels.

Papillœdema, or choked disc, is a condition occurring in the optic disc as a result of increased pressure in the subdural space of the nerve. It was at one time termed optic neuritis, an erroneous designation, since histological examination shows signs only of œdema and not of any inflammatory change. The pathology of the condition can be best explained by reference to figure 2439. It will be seen that increased pressure in the subdural space of the optic nerve will cause interference with the venous and lymphatic return from the disc, which itself is not subjected to any increased compression, since the intra-ocular pressure remains unaltered. The result of this is that the disc becomes swollen and œdematous. It therefore protrudes forwards into the vitreous and also swells laterally, often producing circular folds in the retina, which are concentric with the disc margin. In the classical description of papillœdema, the following stages are recognised with the ophthalmoscope:

(1) Blurring of the upper and lower margins of the disc.

(2) Engorgement and tortuosity of the veins, with blurring which spreads down the nasal side of the disc.

(3) Blurring of the whole disc margin, swelling of the disc itself (shown by the details being visible with a higher convex lens than the rest of the fundus), occurrence of hæmorrhages in about 50 per cent of cases, occurrence of circular folds in the retina round the disc margin, and development of softish white and of stippled areas owing to swelling and varicosity of nerve fibres.

(4) In some cases where the œdema has developed very rapidly, the formation of a macular fan (see fig. 2440).

(5) Overgrowth of neuroglial tissue with subsequent shrinkage causing compression of the blood-vessels and nerve fibres with consequent optic atrophy.

Papillœdema is found in about 80 per cent of all cases of cerebral tumour, and of the 20 per cent in which it does not occur the majority are tumours of the pons or of the centrum ovale. It may also fail to develop if the tumour should cause blockage of the narrow communication between the subdural spaces of the brain and optic nerve. Such a condition may occur in tumours of the pituitary region, of the frontal lobes, and of the third ventricle. In these the optic disc may show a slowly increasing degree of pallor without any œdema, or if the block occurs on only one side, the disc on this side develops pressure atrophy, while on the other side it becomes œdematous.

Optic Neuritis. The majority of these cases are of medical rather than of surgical interest, but it is noteworthy that both syphilis and sinus

infection (particularly sphenoidal) may cause inflammation of the retro-ocular portion of the optic nerve, with resulting diminution of vision and development of a central scotoma for colours. Such a scotoma is also sometimes seen in pituitary tumours when they are growing rapidly, though the most characteristic lesion in these cases is loss of part or whole of the temporal fields of vision.

Optic Atrophy. The characteristic ophthalmoscopic change in this condition is pallor of the optic disc, due to diminution in blood supply and increase in connective tissue. Optic atrophy may arise from a

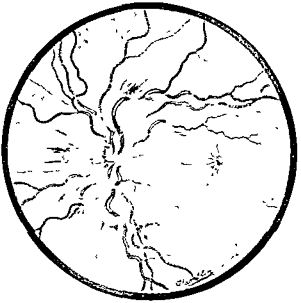

Fig. 2440.—Advanced stage of papillœdema. Note blurring of disc margin, engorgement of veins, presence of striate hæmorrhages, and fan shaped figure at macula

variety of diseases and is best classified according to the site of the causative lesion which may be:

(1) Retinal.

(2) In the disc.

(3) Retro-ocular.

Examples of lesions producing (1) are widespread choroido-retinitis and extensive retinal atrophy: (2) papillœdema, papillitis, glaucoma and high myopia; (3) trauma, pressure by tumours, and spread of inflammation from the meninges.

New Growths of the Optic Nerve.

These are only slightly malignant and are divisible into:

(1) *Extra-dural*; usually endotheliomatous, but occasionally sarcomatous.

(2) *Intra-dural*; endotheliomatous, fibromatous and sometimes gliomatous, i.e. a generalised overgrowth of neuroglial tissue of an infiltrative character.

The optic nerve may, of course, be involved secondarily by spread of growths from the eye (neuro-epithelioma of the retina, sarcoma of the choroid) or brain.

The *signs and symptoms* of a neoplasm of the optic nerve are :

(1) Proptosis, usually straight forwards, the mobility of the eye remaining unimpaired for some time.

(2) Gradual loss of vision, occurring earlier in intra-dural than in extra-dural cases.

(3) Progressive hypermetropia owing to shortening of the eye by pressure from behind.

Diagnosis is often difficult since gummata and other chronic inflammatory masses in the orbit may produce a clinical picture very closely resembling that seen in new growth of the optic nerve.

Treatment consists in removal of the tumour. Resection of the outer wall of the orbit by Krönlein's method or one of its modifications will sometimes allow this to be done without sacrificing the eye.

GLAUCOMA

This is a generic term covering a group of eye conditions in which the intra-ocular pressure is higher than normal. The condition is called primary when it arises without any other lesion being present, and secondary when it is due to some coexisting pathological condition.

Primary Glaucoma may be acute (congestive), sub-acute or chronic (non-congestive or simple).

The pathogenesis of primary glaucoma is not yet definitely known, and it is probable that acute and chronic glaucoma are ætiologically separate diseases.

At first sight one would expect that anything which interfered with the normal drainage of the aqueous through the pectinate ligament into the canal of Schlemm would cause a rise of intra-ocular pressure. That this is so is shown by the observation that glaucoma is a disease of middle or of old age, and is commoner in hypermetropes or in those with a small cornea. Owing to the progressive growth of the lens throughout life it comes to occupy more and more space as the patient becomes older, and the smaller the cornea the more this encroachment is felt.

If an eye which has been excised for glaucoma is examined pathologically it will nearly always be found that the root of the iris has been pushed forward so as to cover the openings into Schlemm's canal at the angle of the anterior chamber (see fig. 2442). In acute glaucoma this is usually due to swelling of the ciliary processes encroaching on the posterior chamber of the eye and so pushing the root of the iris forward,

whereas in chronic glaucoma it may be due to swelling of the vitreous which pushes the whole iris and lens forward as a sort of diaphragm. Recent work seems to show that the determining factor in a case of acute glaucoma may be the presence of some histamine-like substance in the blood which has an endothelio-toxic effect. The endothelium lining the blood-vessels in the ciliary body acts normally as a semi-permeable membrane, so that the intra-ocular pressure represents roughly the osmotic pressure of the proteins in the blood. When this property is interfered with, the pressure of the aqueous approximates more nearly

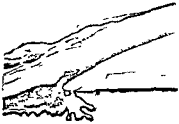

Fig 2441.—Normal eye, showing angle of anterior chamber open. Schlemm's canal is the oval opening in the posterior layers of the corneo-sclera in front of the ciliary body.

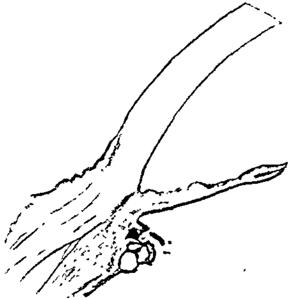

Fig 2442.—Glaucomatous eye showing root of the iris pushed forward and blocking the entrance to Schlemm's canal.

to the general blood-pressure, in addition to which there is severe œdema of the ciliary processes.

Symptoms of Acute Glaucoma.

(1) Pain of trigeminal distribution, often associated with vomiting which may be sufficiently severe to simulate an abdominal emergency.

(2) *Impairment of vision*; this is very marked and the patient may not be able to do more than perceive hand movements. Owing to corneal haze she sees a halo round lights.

Signs of Acute Glaucoma.

(1) Hardening of the eye as estimated by digital palpation. The normal intra-ocular pressure is in the region of 25 mm. Hg., but in acute glaucoma it may be 90 mm. Hg.

(2) Corneal haze, due to œdema of the epithelium and unequal traction on the lamellæ constituting the substantia propria.

(3) Congestion of the conjunctiva, most marked near the limbus.

(4) Shallow anterior chamber.

(5) Dilatation of the pupil which is often oval.

The above signs and symptoms are seen in the fully developed form of the disease. It is not uncommon for the patient to have prodromal attacks first, with less marked symptoms, of which one of the most important is the appearance of haloes round lights.

Symptoms of Chronic Glaucoma.

This may be a very insidious disease and escape notice until irreparable damage has been done, at any rate to one eye. The patient may complain only of gradual diminution of sight frequently associated with temporary attacks of blurred vision and the presence of coloured haloes round lights at night, unassociated with any congestive phenomena unless the disease passes over to the acute or congestive form.

Signs. Some or all of the following may be present:

(1) Dilatation of the anterior ciliary veins.

(2) Shallowness of the anterior chamber and enlargement of the pupil.

(3) Increase of intra-ocular pressure; this may not be present during the time the patient happens to be examined.

(4) Cupping of the disc. The lamina cribrosa being the weakest part of the ocular tunic is the first to yield to increased pressure and becomes displaced backwards. The amount of cupping depends on several factors (e.g. the strength of the lamina cribrosa or the duration of the disease) and is therefore variable. It is associated with pallor of the disc, and if during the time of ophthalmoscopic examination the pressure is raised to a point higher than the diastolic pressure in the central retinal artery, this vessel will be seen to pulsate. A similar pulsation may occur apart from glaucoma if the diastolic pressure is low, as in aortic regurgitation.

(5) Visual field changes. These are of the utmost importance in diagnosis. The earliest sign is usually enlargement of the blind spot, a sickle-shaped extension developing from its upper or lower margin or from both margins, while the peripheral field is first affected in the upper or lower nasal quadrant. Later, the temporal portion becomes affected too. Good central vision may be retained until quite a late stage of chronic glaucoma—a point of considerable importance from the diagnostic standpoint.

Treatment of Acute Glaucoma.

These cases usually require the performance of a wide iridectomy, which has the double effect of reopening the angle of the anterior

chamber and sometimes of providing a leaking scar through which aqueous can percolate. If operation is performed at once, however, there is a grave danger of losing the eye, since in performing it the intra-ocular pressure is suddenly reduced. This may result in a large and destructive intra-ocular hæmorrhage. The following régime is therefore advisable: Send the patient to bed, give her a sharp purge, apply two leeches to the temple on the side of the affected eye and instil into this eye a solution of eserine 1 per cent in ol. ric., every half-hour for two hours and then two-hourly. It is well to put a drop into the unaffected eye too. Fomentations may be applied and, if the pain is severe, morphia should be given. In the absence of marked hyperpiesis a single intravenous injection of hypertonic saline (50 cc. of a 30 per cent solution, given by funnel and tube over a period of 10 minutes) may be of great assistance in reducing intra-ocular pressure. After 12 to 24 hours of treatment it will usually be safe to perform iridectomy under a general anæsthetic.

Treatment of Chronic Glaucoma.

This is either by myotics or operation. The purpose of the former is to keep the pupil contracted, thus opening up the angle of the anterior chamber and increasing the absorbing surface of the iris. The purpose of the latter is to provide a fistula through which the aqueous can drain away into the sub-conjunctival space. Numerous operations have been devised for this purpose, corneo-scleral trephining being the one most commonly employed.

With regard to myotics, pilocarpine ($\frac{1}{2}$–1 per cent in water) may be used once or more in the twenty-four hours according to the severity of the case, and if this does not prove efficacious eserine ($\frac{1}{4}$–1 per cent in water or oil) should be employed. The patient must be carefully watched for decrease in size of the visual fields and of degree in visual acuity, and also for increase of cupping. If any of these should occur, myotic treatment must be discontinued and operation performed.

Infantile Glaucoma.

Congenital malformation of the canal of Schlemm or of the pectinate ligament, or the occurrence of peripheral anterior synechiæ in infancy prevents drainage of the aqueous and leads to glaucoma. Since the cornea and sclera are distensible in infancy the eye undergoes a uniform enlargement, so that it comes to resemble that of an ox, the condition being called buphthalmos.

Corneo-scleral trephining holds out the best chance of cure, though the operation may have to be repeated several times.

Secondary Glaucoma.

This may arise from many different causes, of which the following are the most important:

(1) Perforating wounds or ulcers of the cornea.

(2) Increased viscidity of the aqueous, e.g. in certain cases of iritis and after injury to the lens.

(3) Annular synechia of the iris (see page 4537). New growths of the root of the iris or of the ciliary body.

(4) Swelling of the lens, as occurs in some cases of senile cataract, also dislocation of the lens.

(5) Large intra-ocular hæmorrhages.

(6) New growths of the retina or choroid.

Treatment of secondary glaucoma must obviously be directed to the causative condition. In cases where the eye is irremediably blind and painful, it is better excised.

INJURIES TO THE EYE

Some of these have already been described; the following, however, remain to be noted:

Eyelids. The swelling and discolouration of the lids after a blow on the eye are sufficiently well known to need no description. If seen early, the application of a small ice-bag or of evaporating lotion may limit the amount of swelling. Lead lotion should never be used if there is any suspicion of injury to the cornea because of the danger of producing a permanent opacity. Extravasation of blood into the upper lid may occur some hours after a head injury, particularly if the skull has been fractured. If fracture of the orbital wall has occurred, surgical emphysema may develop in the lids owing to communication with one of the sinuses. In such cases the patient should be warned not to blow her nose.

In examining a case of injury to the lids the possibility of a perforating wound of the eye should always be borne in mind.

For injuries of the conjunctiva see page 4526.

Cornea. The commonest type of corneal injury is due to the lodgment of a foreign body, the presence of which may be easily missed, even when the eye is examined with a loupe and oblique illumination. In cases of doubt the following points may be of assistance:

(1) The history—if the patient complains of a "pricking" pain there is very likely to be some corneal injury.

(2) Contraction of the pupil in the affected eye, and the presence of

some circumcorneal congestion often at a point on the limbus nearest to the foreign body.

(3) The effect of fluorescein, which gives a green stain to any portion of the cornea where the epithelium has been damaged.

(4) Distortion of the reflection formed by the cornea of a window.

Treatment. The eye should be cocainised (2 or 3 drops of 4 per cent cocaine at 3-minute intervals) and an effort made to wipe off the foreign body with some cotton wool wound round the end of a glass rod and dipped in boric lotion. If this fails, a discission needle will have to be used, the surgeon looking through a "loupe" (see fig. 2430) under good oblique illumination, as otherwise unnecessary damage may be done to the cornea. A drop of oily homatropine and cocaine (equal parts 2 per cent) should then be instilled and the eye bandaged. A pad should be kept on for 24–48 hours and the patient instructed to bathe her eye with boric lotion night and morning for the next few days. It is also advisable to put a drop of parolene into the eye every night during this period.

If the foreign body is at all deeply placed in the cornea, its removal should not be attempted except by an ophthalmic surgeon, as the foreign body may slip through into the anterior chamber and its removal necessitate the performance of an intra-ocular operation.

Injuries to the *globe* of the eye may be penetrating or non-penetrating. In the latter, the following conditions may occur:

(1) Abrasion of the cornea—shows up green with fluorescein and usually heals over in a few days. Atropine and a pad and bandage are of service in relief of pain and promotion of rapid healing.

(2) Permanent enlargement of the pupil owing to radial tears through the sphincter iridis. Sometimes the tear occurs at the periphery of the iris, producing "irido-dialysis" with a consequent D-shaped pupil, owing to the detached portion of iris being pulled down. Both these conditions are liable to be associated with hæmorrhage into the anterior chamber and sometimes with "blood-staining" of the cornea.

(3) Affections of the lens. Rupture of the suspensory ligament, according to its extent, will cause partial or complete dislocation of the lens. In the former event, even though the lens is still present in the pupil, the power of accommodation is lost, and if the lens margin should happen to cross the pupil, monocular diplopia may occur. When the lens is completely dislocated it usually falls back into the vitreous where it may be left unless glaucoma supervenes, which is not an uncommon event. If the lens passes into the anterior chamber, glaucoma is almost certain to occur and necessitate a somewhat hazardous opera-

tion. Traumatic cataract *may occur apart from any perforation*, and usually manifests itself first at the posterior pole of the lens. In some cases the opacity clears up, but in others it remains or spreads to involve the whole lens. A ring of fine dots sometimes appears on the anterior capsule (Vossius' ring) and usually disappears in a week or two.

(4) Affections of the vitreous. The occurrence of hæmorrhage into the vitreous is common after a blow on the eye. It absorbs slowly, but if extensive, may organise into fibrous tissue.

(5) Retina. *If a tear occurs in this membrane, detachment may follow (see page 4544). Milder degrees of injury comprise the occurrence* of hæmorrhages and of œdema. The latter is known as "commotio retinæ" and usually develops at the posterior pole of the eye, causing marked impairment of vision. This, however, lasts only a few days, after which the eye regains its normal visual acuity, unless a "hole" has developed at the macula. The pathology of this condition is still obscure, but its effect is to abolish foveal vision and so reduce acuity.

(6) The choroid *is more vulnerable than the retina, and it is not uncommon to find tears in it when the overlying retina is intact.* Such tears are usually concentric with the disc margin and are often found between it and the macula. In the early stages they may be concealed by blood, but later on they show up as atrophic white or yellowish-white areas, with possibly some pigmentary disturbance.

Detachment of the choroid is seen more commonly after operations for glaucoma and cataract than after injuries. The detached portion appears ophthalmoscopically as a dark mass and usually goes back into position in the course of a week or two.

Treatment. Rest in bed, and the application of a pad and bandage, *and possibly of a cold compress, are advisable. Atropine is also of* help in keeping the eye at rest.

Perforating injuries are divisible into two classes:

(1) *Without retention of a foreign body.* As already explained, the commonest site for a rupture of the globe is at the upper and inner quadrant of the limbus. In such cases the iris will probably be prolapsed into the wound and the lens may be dislocated towards the wound too, or even expelled from the eye altogether. Such cases are serious, not only to the injured eye, but on account of the risk of sympathetic ophthalmitis (see page 4557), and require operative treatment.

Small corneal wounds heal readily but leave an opaque scar, which may be of no consequence unless it involves the pupillary area. If the iris has prolapsed into the wound, as shown by irregularity of the

pupil margin and the presence of a dark area in the scar, operative measures are urgently needed to remove the incarcerated iris.

Sometimes an eyelash is driven into the anterior chamber where the cells at its base may continue to grow and form an epithelial " pearl." If the lens is wounded, traumatic cataract develops, which may remain localised or become complete according to the time taken for the rent in the capsule to close. Penetrating injuries further back are often associated with escape of vitreous, and with prolapse of the ciliary body or choroid.

Such injuries may again form the starting-point of sympathetic ophthalmitis.

If micro-organisms are introduced into the eye at the time of the injury, all grades of inflammation may occur from a mild iritis to panophthalmitis. Other things being equal, the anterior part of the eye is more resistant to infection than the part which contains the vitreous.

Treatment of these cases calls for considerable judgment and experience. On the one hand, if the eye is retained, binocular blindness may eventually result from sympathetic ophthalmitis, while, on the other hand, an eye which may later become quite a useful organ of vision may be unnecessarily sacrificed by early removal.

(2) *With retention of a foreign body.* The foreign body may be visible in the anterior chamber or lens, or be seen in the vitreous with the ophthalmoscope, provided there is not much hæmorrhage or traumatic cataract. If not visible, X-rays should be used, since by this means it is possible not only to establish the presence of an intra-ocular foreign body, but also to localise it. The importance of the history in such cases is obvious, particularly in finding out whether the foreign body is magnetic or not, since on this depends the treatment adopted.

The wound of entrance may be quite small, and is easily missed unless the surgeon has the possibility of its presence in mind. In addition to examination of the cornea, the sclera should be carefully gone over with a loupe, the patient being asked to look in various directions so as to expose as much of its surface as possible. Sometimes a hole in the iris or a small opacity in the lens will give a clue.

Treatment is a matter for the ophthalmic surgeon—if the foreign body is magnetisable it may be possible to remove it with an electro-magnet, but if not, it may be necessary to open the eye, though in many cases non-magnetic foreign bodies (e.g. glass) are best left alone.

Prognosis is grave, and " follow-up " work indicates that even in cases when the foreign body is removed by a magnet it is only a small percentage of eyes which retain useful vision.

Sympathetic disease occurs in two forms:

(1) Sympathetic irritation, which is a reflex functional condition in *one eye following on a lesion which irritates the trigeminal filaments* in the other eye. It is not dangerous to sight, and disappears promptly on removal of the cause in the " exciting " eye.

(2) Sympathetic ophthalmitis. This is a plastic inflammation of the uveal tissue in one eye (the sympathising eye) which follows a similar lesion brought about by a perforating injury in the fellow eye (the exciting eye).

Ætiology. The disease is particularly likely to occur when the injury to the exciting eye has involved prolapse of the iris, ciliary body or choroid. Of these three structures, the ciliary body is the most likely to give rise to sympathetic ophthalmitis, for which reason the zone of sclera overlying it is designated the " dangerous area." Apart from perforating lesions of the eye, sympathetic ophthalmitis has sometimes *been found to follow necrosis of a melanotic sarcoma in the fellow eye.* The actual cause of the disease is still a matter of speculation as no organism has been found. It has been ascribed to latent tuberculosis, to a staphylococcus to which the eye has become sensitised, to some form of spirochæte, to a virus, and finally to allergic hypersensitivity of the patient to his own uveal pigment. If suppuration occurs in the "exciting eye", *it seems to prevent the occurrence of sympathetic inflammation.*

Signs and Symptoms. There is always active iridocyclitis in the exciting eye, usually of the plastic type, associated with the formation of a sticky exudate which binds the iris down to the lens. There are also abundant deposits of precipitate on the back of the cornea.

In the sympathising eye, *there are sensitiveness to light,* some impairment of vision, and weakness of accommodation. On examination, there may be some precipitate on the back of the cornea and a few opacities in the vitreous. If untreated, or in many cases in spite of the most vigorous treatment, the disease pursues a relentless course; the choroid becomes involved, the lens opaque, and the retina detached so that finally *the eye is left blind, shrunken and useless.* In a fair proportion of cases secondary glaucoma ensues owing to widespread adhesions between the iris and lens.

Prophylaxis.

The question of removal of an injured eye may be a very difficult one to decide, and in a given case opinions will often vary. The following *indications may, however, be of service: Enucleation should be performed on:*

(1) An eye so severely injured as to destroy sight at once or to make its ultimate destruction reasonably certain.

(2) An eye with a retained foreign body which has resisted efforts at extraction and in which severe iridocyclitis is present.

(3) An injured eye which shows no signs of quietening down after two or three weeks of treatment, provided the fellow eye has reasonably good vision.

If sympathetic ophthalmitis has already started, the exciting eye is better left if it has any useful sight, since it may ultimately have the better vision of the two. If only sympathetic irritation be present the exciting eye should be removed.

Treatment. The local treatment consists of hot bathing, atropine, dark glasses, and the application of leeches to the temples. With regard to general treatment, the patient should be confined to bed, given hot air baths to promote sweating, and be put on to large doses of sodium salicylate (working up to one grain per day for each pound of body weight). A course of injections of salvarsan or of N.A.B. should also be given. Many other remedies have been used in this disease and good results have been claimed from the injection of large doses of diphtheria antitoxin. Removal of infected teeth or tonsils and treatment of alimentary toxæmia are obvious precautions.

Prognosis is essentially grave, but not necessarily hopeless. If treatment can be begun within the first week one authority states that 75 per cent of cases retain useful sight.

STRABISMUS OR SQUINT

There are two main varieties of squint: paralytic or non-comitant, and non-paralytic or concomitant.

Paralytic strabismus is due to paralysis, partial or complete, of one or more of the extra-ocular muscles. It presents the following characteristics:

(1) Lack of parallelism between the visual axes.

(2) Diplopia.

(3) Vertigo.

(4) Defective movement of the affected eye, not always evident (e.g. in paresis of one superior oblique muscle).

(5) False projection.

All these are increased when the affected eye attempts *to look in the* direction of action of the paralysed muscle.

(6) Tilting or twisting of the head, again in the direction of action of the paralysed muscle.

(7) The secondary deviation is greater than the primary, i.e. if the patient attempts to look at an object with the affected eye the deviation of the sound eye will be greater than that of the affected eye when he fixes the same object with the sound eye.

In examining a case of paralytic squint it may be sufficient merely to ask the patient to look in various directions and note in which of these the movement of the eye is defective, but it is usually necessary to examine for diplopia as well. This is done by holding a lighted candle, or other source of illumination, in front of the patient and moving it into the nine cardinal positions as shown on the chart (fig. 2443). In order to distinguish the images seen by the two eyes, a red glass is held in front of the right eye.

Diplopia occurs because the patient imagines that the eye with the

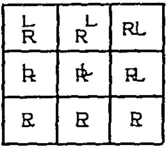

Fig. 2443.—Chart to show diplopia produced by paralysis of left superior rectus. R Image seen with right eye. L Image seen with left eye, in the nine cardinal positions.

paralysed muscle is pointing in the same direction as its fellow. Suppose she has paralysis of the left internal rectus. On attempting to look at a candle flame on the right, the right eye will move so that the image falls on the fovea F (see fig. 2445), whereas the left eye will remain looking straight ahead, and the image will fall to the temporal side of the fovea F′ at O′. Now the patient imagines her fovea is at O′, and as the image is on the temporal side of the fovea, she imagines the object to be on the nasal side of O, i.e. at O″, i.e. the apparent displacement of the object is in the direction of action of the paralysed muscle. In other words, if the muscle cannot move the eye, it will move the image. To interpret a diplopia chart, therefore, all that is needed is a knowledge of the actions of the extra-ocular muscles.

The actions of the internal and external recti are simple and need no comment; the other four muscles, however, are more complicated and are best understood by considering their actions as "primary" when the eye is looking in the direction of the muscle tendon and "secondary" when the eye is looking at right angles to the line of action of the muscle. Figure 2446 A gives a diagrammatic representation of the left eye with the superior rectus and superior

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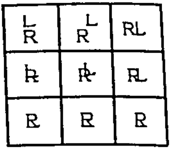

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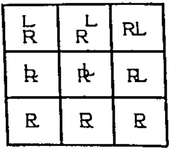

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oblique muscles—only the reflected tendon of the latter being shown. If the eye be imagined as transparent, the same diagram will serve for the inferior rectus and inferior oblique muscles.

In figure 2446 B contraction of the superior rectus would cause the eye to turn upwards and of the inferior rectus downwards. In figure 2446 C, however, the insertions of the superior and inferior recti are carried

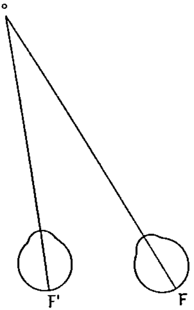


Fig 2444.—Case of left internal rectus palsy. Both eyes looking at O to the left of the mid-line. The image of O falls on the fovea of each eye (F' and F) and O is therefore referred to its proper position.

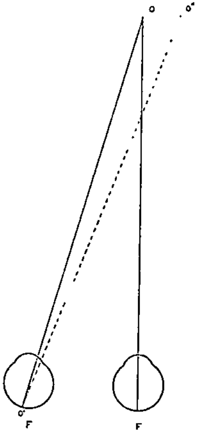


Fig 2445.—Case of left internal rectus palsy. Both eyes attempting to look at O when it is to the right of the mid-line. Image falls on fovea of right eye but not of left eye.

inwards so that contraction of either of these muscles would also cause the eye to turn further in towards the nose, i.e. adduction would occur. In the same way one can see the actions of the oblique muscles. In figure 2446 C the eye is looking more or less along the line of the oblique tendons so that contraction of the superior oblique would cause the eye to turn down, and contraction of the inferior oblique would cause the eye to turn up. In figure 2446 B, however, when the eye is looking along a line almost at right angles to the tendon, contraction of either oblique

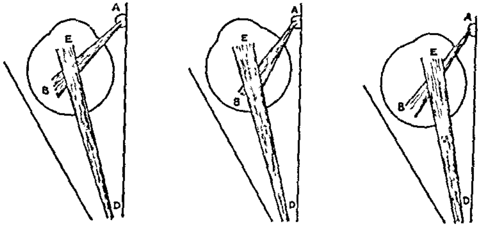


Fig. 2446. A B C

muscle would cause the eye to turn outwards, i.e. would bring about abduction. We are thus able to classify the actions of these four muscles as follows:

Muscle.	Principal action.	Subsidiary action
Superior Rectus.	Elevation, at a maximum in *abduction*.	Adduction, at a maximum in *adduction*.
Superior Oblique.	Depression, at a maximum in adduction.	Abduction, at a maximum in abduction.
Inferior Oblique.	Elevation, at a *maximum* in adduction.	Abduction, at a maximum in abduction.
Inferior Rectus.	Depression, at a maximum in abduction.	Adduction, at a maximum in adduction.

The application of this can be seen in elucidating the diplopia chart (see fig. 2443). The steps would be as follows:

(1) The left image is the more displaced, therefore the left eye is the paretic one (if the muscle cannot move the eye it moves the image).

(2) The displacement occurs when the eye is looking up, therefore the muscle at fault is the left superior rectus or left inferior oblique.

(3) The muscle acts as an elevator when the eye is abducted, and as an adductor when the eye is adducted, i.e. it is the left superior rectus.

In actual practice the matter is not always as simple as this, since more than one muscle is often involved, and there may be other complicating factors such as pre-existing defects of balance between the extra-ocular muscles of the two sides, but the same principles can often be applied, even in these cases.

Ætiologically, the causes of ophthalmoplegia are numerous, and may be grouped as below:

(1) Congenital. Aplasia of a muscle.

(2) Traumatic. Hæmorrhage into the muscle sheath, division of a

muscle by a penetrating injury, fracture of the base of the skull involving nerve injury, and exposure to cold.

(3) Inflammatory. This group is best considered under four headings:

(*a*) Inflammation proper. Basal meningitis, formation of gummata or of tuberculous masses, lethargic encephalitis, and peripheral neuritis.

(*b*) Vascular. Hæmorrhage, thrombosis, embolism, pressure or rupture of aneurysms, and pressure of sclerosed arteries.

(*c*) Toxic. Alcohol, lead, botulism, diphtheria and influenza.

(*d*) Where the palsy forms part of some more general disease, e.g. tabes, general paralysis, disseminated sclerosis, syringomyelia, postero-lateral sclerosis, paralysis agitans, progressive muscular atrophy and myasthenia gravis.

(4) Neoplastic. Glioma, endothelioma, etc., while in a certain number of cases the ætiology is unknown.

Syphilis is the commonest single cause, so that performance of a Wassermann reaction is usually the first step in elucidating the cause of paralytic strabismus.

The lesion may occur at any point in the neuro-muscular path.

Concomitant Squint. This is an entirely different condition from that just considered and is easily diagnosed from it by the fact that the angle of deviation remains approximately the same when the eyes are moved in various directions. The essential defect is not in the muscles, the nerves or their nuclei, but is in the higher centres of the brain, probably that portion of it which is associated with the power of binocular vision. If this power be well established, the images in the two eyes are blended provided the eyes are looking in the same direction. If the visual axes of the two eyes deviate, diplopia at once occurs. Where the power of binocular vision is weak or absent, however, deviation of one eye does not cause diplopia because the vision of this eye is suppressed, so that the eyes, even if straight, are in a state of unstable equilibrium and deviation may occur on the slightest provocation, the commonest being uncorrected hypermetropia and astigmatism. The usual age for a squint to develop is between two and three years, though it may be much earlier.

Diagnosis is in many cases obvious, but if the deviation is only slight the following procedure should be carried out: Seat the child in a moderately dark room and hold in front of her, at a distance of about two feet, a small source of light such as the lamp of an electric ophthalmoscope. A baby will at once look at the light, and an older child should be told

to do so. The observer should note the position of the corneal reflex in the two eyes when he is looking over the light. If the reflexes are symmetrically placed in the two corneæ there is no squint. If doubtful about the symmetry, cover first one eye, then the other, and note if there is any movement. Suppose, for example, that the child has a right convergent squint. The corneal reflex in the left eye will be near the centre of the pupil, whereas in the right eye it will be to the temporal side of the cornea. If the right eye now be covered, the left eye will continue to look at the light as before. On uncovering the right eye and covering the left, however, the right eye will be seen to make a distinct movement outwards in order to look at the light. The only exception to this is when the squinting eye has such poor vision that it has lost the power of central fixation. In such a case, however, the deviation will be sufficiently obvious not to need the cover test for its demonstration.

Varieties of Concomitant Squint.

In the first place the squint may be convergent or divergent, the former being the commoner. It may also be:

(1) Periodic, in which the squint is not always present, or

(2) Constant. Also it may be

(3) Unilateral, where only one eye squints; or

(4) Alternating, where the squint may occur in either eye.

In the latter case the visual acuity in the two eyes is approximately the same.

Treatment. Only the bare outlines of this can be given here. The first essential is the prescribing of glasses to correct the error of refraction in the two eyes. If the case be an early one, this alone may suffice to put the eyes straight; if not, steps must be taken to prevent the squinting eye becoming relatively blind from disuse. To this end, the straight eye may be kept covered or its sight may be blurred by keeping it under atropine and without a correcting lens. When approximately equal visual acuity has been obtained by these means, attempts should be made to produce binocular vision by "fusion training," i.e. exercises with various modifications of the stereoscope. In some cases this is successful, in others an operation must be performed to restore the eyes to approximate parallelism before binocular vision can be obtained.

In a certain number of cases, the squinting eye remains relatively blind ("amblyopia ex anopsia") in spite of all treatment, and in such cases operation is usually performed for cosmetic reasons.

Divergent Squint. The majority of concomitant squints are convergent; the divergent variety can, however, occur, and is associated

with myopia. It most frequently appears at ten to twelve years of age, is more commonly alternating than unilateral, and is seldom constant. It is probably caused in the following way:

The myopic child who is without glasses has to hold her books very close in order to see them clearly. This entails such a high degree of convergence that she gives up the struggle, and allows one eye to wander outwards, and reads in comfort with the other. Fusion training and the wearing of correct glasses are usually enough to correct the condition, operation being seldom required except where convergence has become defective through disuse. In these cases, advancement or shortening of an internal rectus may add greatly to the patient's comfort.

Occasional divergent squint is not an uncommon condition, and is frequently familial, one or other eye turning out when the patient's thoughts are wandering. There is seldom any notable error of refraction, and though fusion training may sometimes help, operation is often required. Before performing this, one or other eye should be covered for several weeks so that it may assume its position of rest and the surgeon can see how much needs to be done. The external recti should not be touched, the whole effect being produced by shortening of one or both internal recti.

Another form of divergent squint is that seen in a blind eye which usually tends to deviate outwards, and finally there is the type which follows too free a tenotomy of the internal rectus for the cure of convergent squint.

CHAPTER II

Ophthalmic Operations

PRELIMINARY CONSIDERATIONS

Only a small proportion of operations on the eyeball or its adnexa are in the nature of emergency procedures. It is therefore possible to ensure that the patient is in the best possible physical condition before anything is done, and a thorough general overhaul should be carried out, particular attention being paid to the elimination of focal sepsis, the presence of high blood-pressure and of albumen or sugar in the urine. Local conditions must also be investigated, particularly if an intra-ocular operation (e.g. cataract extraction) is to be performed. The lachrymal passages should be examined for patency, a conjunctival smear and culture, incubated for forty-eight hours, should be taken, and the lid margins carefully inspected. It is usual to administer a mild laxative twelve hours before operation.

Anæsthesia. The majority of intra-ocular operations are performed under local anæsthesia, induced by the instillation of sterile 5 per cent cocaine drops at five-minute intervals over a period of half an hour. The lids should be kept closed, except when the drops are being instilled, so as to prevent opacity developing in the corneal epithelium. In nervous patients it may be necessary to administer some sedative, e.g. paraldehyde 2 drachms in diluted syrup or one of the barbiturates, an hour before operation, while in others who are still more nervous, intravenous evipan has been used with success. In cases where the eyeball is congested, as in acute glaucoma, cocaine drops fail to produce adequate anæsthesia, and resort has to be made to the injection of 1 cc. of 4 per cent novocaine, possibly with adrenalin. This is injected beneath Tenon's capsule in the upper and outer quadrant of the eyeball.

In operations not involving opening of the eyeball post-operative vomiting has not the same risk, so that general anæsthesia can be employed, though in many cases infiltration with novocaine and adrenalin is preferred.

Antisepsis. The skin surrounding the eye should be painted with 1 per cent tincture of iodine, and the conjunctival sac well washed out with 2 per cent boracic lotion. In squint operations, the patient's face

should be covered with a mask in which there is a slit for exposure of the eye, so as to avoid contamination of the stitches by contact with the skin of the face.

Position of the Surgeon. For practically all eye operations the surgeon stands or sits at the head of the table, i.e. behind the head of the patient.

OPERATIONS UPON THE LIDS

(1) *Spasmodic Entropion.* The skin of the lower lid is infiltrated with novocaine. An oval area, varying in size according to the degree of defect, but usually about 30×6 mm. is picked up in special forceps (fig. 2447) and removed with straight scissors. After checking hæmorrhage, a similar area of the exposed orbicularis muscle is grasped with

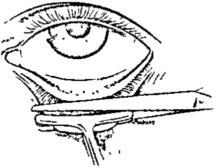


Fig. 2447.—REMOVAL OF SKIN IN SPASMODIC ENTROPION.

fixation forceps and also removed with scissors. The wound is united with three or four interrupted silk sutures which are removed on the fifth day. No dressing is required.

(2) *Cicatricial Entropion.* The commonest form of this is due to cicatricial contraction following trachoma and causing inversion of the upper lid, so that the lashes are constantly rubbing and irritating the cornea. In mild cases it suffices to remove the misplaced lashes by forceps or by electrolysis, but where the lid is badly deformed some plastic procedure is called for. Numerous operations have been designed for this purpose. One which gives satisfactory results is the muscle-tarsal operation of Hotz and Anagnostakis, which is performed as follows under infiltration anæsthesia:

Insert a horn spatula under the upper lid, and make a skin incision along its whole length, 3 mm. from the margin (fig. 2448). Dissect up the skin and expose the tarsal cartilage by removal of the overlying muscle-fibres. Apply a sharp scalpel to the cartilage, parallel to its

plane, and with a downward sawing movement cut away thin slices, avoiding perforation. The upper and lower margins of the cartilage are not included in the area thus dealt with. Three sutures are now passed as shown in figure 2448. In each, the needle perforates the skin at the upper margin of the incision, and is carried through the upper border of the tarsal cartilage from behind forwards, and then through the lower margin of the skin incision. The effect of tying these sutures is to drag the lower border of the skin wound to the level of the top of the tarsal cartilage and thus make the lid concave forwards. This over-correction disappears in a few days, and the lid assumes its normal

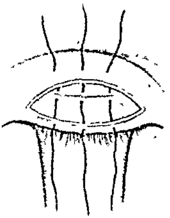


Fig 2448.—Hotz-Anagnostakis operation to show insertion of sutures.

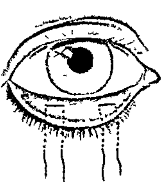


Fig 2449.—Snellen's sutures for spasmodic ectropion.

position. The eye should be covered with a dressing, and the stitches can be removed on the fifth day.

(3) *Ectropion.* The spasmodic variety can be dealt with by Snellen's sutures. Two doubly-armed stitches are used. These are passed through the most prominent part of the swollen conjunctiva (fig. 2449) and made to penetrate the skin over the lower margin of the orbit, being tied over a piece of rubber tubing, and removed in eight days. *Cicatricial ectropion* may follow burns and wounds of the face, and may require extensive plastic procedures for its cure. *Senile ectropion* is not uncommon and is due to atrophy of the obicularis often combined with chronic catarrhal conjunctivitis. As a result of the lid falling away from the eyeball there is interference with drainage of the tears, and the eye is constantly watering; the exposed conjunctiva is irritated and inflamed which increases the watering, and a vicious circle is thus set up. In mild cases it suffices to make two linear applications of the actual cautery to the conjunctiva lining the lower lid, subsequent cicatricial

contraction drawing the lid back into position. A similar result may sometimes be achieved by a few applications to the conjunctiva of 2 per cent silver nitrate at intervals of one day.

In more marked cases it is necessary to shorten the lid. Theoretically, this could be done by excising a wedge involving the whole thickness of the lid, and suturing the margins of the defect. The result is not satisfactory, however, because an unsightly gap remains in the lid margin. It is advisable, therefore, to perform the following operation (Kuhnt-Szymanowski) under infiltration anæsthesia: The lower lid is grasped between the finger and thumb, and a thin keratome is introduced at a point slightly towards the inner side of it and just behind the lashes. The blade of the keratome is then pushed on so as to separate the tarsal and cutaneous layers. This procedure is repeated

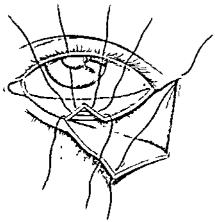


Fig. 2450—KUHNT-SZYMANOWSKI OPERATION. THE TRIANGLE OF TARSAL CARTILAGE HAS BEEN REMOVED, ALSO THE TRIANGLE OF SKIN, AND THE SUTURES ARE INSERTED READY FOR TYING.

until the outer half of the lid is split. A triangular piece of tarsal cartilage and conjunctiva is now removed with scissors, the amount removed being proportional to the degree of defect requiring correction. A triangular skin incision is made as shown in figure 2450, and the skin carefully dissected up and removed, the skin of the lower lid mesial to it being undermined. The lash-bearing portion of this is removed, and sutures are inserted. When these are tied, the lid will have been shortened by an amount corresponding with the width of the triangle. A dressing is applied, both eyes being kept covered for four days. At the end of this period the tarsal sutures are removed, the skin sutures being taken out a day or two later.

Ptosis. There are two principal operations performed for this condition. If the superior rectus is active, the tarsal cartilage of the upper lid can be attached to it, and so enable the lid to be raised when

the eye looks up (Greeve's operation). The technique of the operation is as follows: The eye is rotated downwards by traction on a stitch passed through the conjunctiva just above the limbus, and the superior rectus tendon is exposed by a transverse incision through the conjunctiva (fig. 2451). The muscle is isolated and a silk thread passed under it. The upper lid is everted and the conjunctiva above the incision is dissected up so as to expose the upper edge of the tarsal plate. The latter is then gripped in a pair of catch forceps and incisions are made in it as shown in fig. 2451, diagram A. The strips of cartilage are turned upwards and sutured with No. 1 silk to the sides of the superior rectus tendon in such a position that the edge of the lid just overlaps the upper

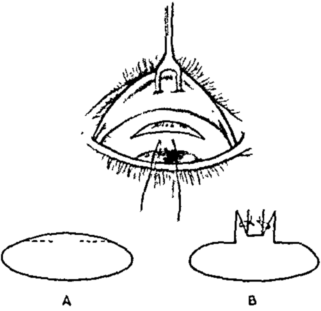


Fig. 2451.—Greeve's operation, showing upper lid retracted and superior rectus tendon exposed through conjunctival wound.

margin of the cornea. A sausage-shaped pad is then placed over the upper lid so as to keep the eye closed, and is kept in place with strapping and a bandage. The stitches are removed on the tenth day.

After healing has occurred it may be necessary to excise a redundant horizontal strip of skin of the upper lid.

In cases where the superior rectus is paralysed, another type of operation is employed. This consists in using strips of skin to pull the upper lid into place, and to attach it to the occipito-frontalis muscle. Both these operations and the following one may be performed under local or general anæsthesia. The procedure about to be described was devised by Machek and modified by Gifford:

A horn spatula is introduced beneath the upper lid, and two horizontal incisions are made through the skin parallel with the lid margin,

the lower of these being 3 mm. distant from it, and the upper 6 mm. (fig. 2452). The incisions begin at a distance of 3 mm. from the outer and inner angles of the eye respectively. Two incisions are then made above the eyebrow and, by means of a pair of scissors, vertical tunnels are made to the ends of the skin flap in the upper lid. The flap is then divided and the straps of skin are drawn upwards by forceps and stitched to the margin of the wounds in the eyebrow (fig. 2453).[1] The effect can be varied by altering the length of the eyelid incisions and by the degree of tension imposed on the skin flaps. The stitches are tied over rubber tubing and are not usually removed until the fourteenth day. At the end of the operation the upper lid is usually drawn

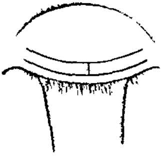


Fig 2452.—Skin strap operation for ptosis. Lines of incisions indicated

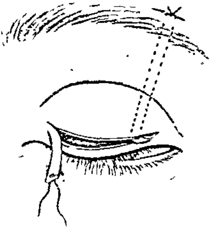


Fig 2453.—Skin strap operation, showing how straps are drawn up and fixed with a suture above the brow.

up to such an extent that it is impossible to close the eye. An air-tight dressing has, therefore, to be used, in order to prevent drying of the cornea. This can be effected by means of a cone of X-ray film, cleansed of its emulsion and bound at its sharp edges by adhesive tape. The cone is cut before the operation and is made to a size to fit the orbital margin. It is kept in place with strapping, and being transparent it allows of inspection of the cornea.

Tarsorraphy. In some corneal conditions, particularly in neuroparalytic keratitis, the only hope of saving the eye is to unite the lids. This is easily effected by removing the sharp posterior margin of the upper and lower lids with a pair of scissors and bringing the raw surfaces into apposition with three sutures. It is customary to unite only the

[1] Some authorities advise the destruction of the epithelial cells on the flaps by the application of trichloracetic acid.

middle third in this way, and the sutures (double-armed) are best passed from the conjunctival surface of the lid forwards. They are removed at the end of a week, a dressing being applied after the operation. When the cornea is anæsthetised it is well to leave the adhesion undisturbed for a period of three months and then gradually to cut it through 2 to 3 mm. every week until an adhesion about 1 mm. broad is left opposite the temporal margin of the cornea. The deformity produced by such an adhesion is only slight, and the protection supplied by the partial closure of the lids is usually sufficient to prevent the development of keratitis, and to bring about healing of any defects which may have occurred.

OPERATIONS UPON THE LACHRYMAL APPARATUS

(1) *Syringing.* After instillation of cocaine, the lower lid is everted and a Nettleships dilator is introduced into the lower punctum, so as to enlarge it sufficiently to allow the entry of a lachrymal cannula. The latter, with syringe attached, is then passed along the canaliculus and an endeavour is made to syringe fluid through into the naso-lachrymal duct. If the patient inclines his head forward, fluid will be seen to pass out of the nose if the passages are open. If there is a block, fluid, with or without muco-pus, will regurgitate from the upper punctum. Should this occur, the syringing may be repeated for several days and, if it is still not possible to obtain an opening, a probe may have to be passed. In order to do this, the sac should be filled with cocaine and adrenalin solution so as to render the procedure as painless as possible. The passage of the probe is a somewhat difficult matter calling for considerable experience. The probe should first be passed in a direction parallel to the lid margin until its end can be felt to impinge on the inner wall of the sac. The probe is then turned upwards so as to make it point towards the junction of the ala of the nose and the side of the face. An attempt should be made to pass the probe downwards along the naso-lachrymal duct. In order to effect the passage of any but the smallest probes, it is usually necessary to slit the canaliculus.

(2) *The Three-Snip Operation.* This is employed in cases where, owing to slight drooping of the lid, the lachrymal punctum is everted with resulting epiphora. The operation is performed under local anæsthesia, a little solid cocaine being rubbed into the conjunctiva of the lower lid near the inner canthus.

After dilatation of the punctum, a Stillings or Weber knife is passed along the canaliculus, with the cutting edge directed backwards so as to slit open the canaliculus (see fig. 2454). A pair of fine forceps is now made

to grasp the posterior layer of the lid, and with scissors a triangular portion of it is removed. By this means a relatively large communication is made between the lacus lachrymalis and the canaliculus.

(3) *Removal of the lachrymal sac.* This operation is performed as a last resort in obstinate cases of dacryo-cystitis. It is carried out under local anæsthesia, the skin and deep tissues round the sac being thoroughly infiltrated with novocaine and adrenalin and the sac itself washed out with 3 per cent cocaine solution. The incision begins at a point 3 mm. above and internal to the inner canthus and is carried downwards and outwards for a distance of 2 cms. After division of the skin, the margins are dissected up and a special speculum (fig. 2455) is inserted. An endeavour should now be made to locate the anterior lachrymal crest by feeling with forceps along the inferior margin of the orbit on to the

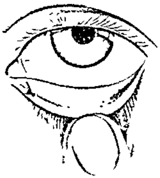


Fig. 2454.—Three-snip operation, showing the canaliculus slit up and the portion of conjunctiva removed.

side of the nose. An incision is made with the sharp point of the scissors so as to divide the fascia along a line $\frac{1}{2}$ mm. behind the anterior lachrymal crest, the internal canthal ligament being cut through at the upper end of the incision. A little dissection will then allow exposure of the sac, the latter being freed from its surroundings with the points of the closed scissors. In doing this the canaliculi will be cut through. The sac may now be grasped with forceps and pulled forwards a little, so as to allow of its upper end being freed. Hæmorrhage may occur at this point, but can easily be checked by the application of swabs soaked in adrenalin. The sac is now free except for its lower end. The wall here is divided as far down as possible by passing the scissors down the naso-lachrymal duct. After the removal of the sac, the duct should be gently curetted with a sharp spoon, and if any fragments of mucous membrane have been left, they can be destroyed with an electric cautery at a dull red heat. The skin is united by interrupted sutures which are removed after

four days. The dressing should incorporate a small pad of gauze to lie over the line of the incision. The cornea should be carefully inspected for scratches or abrasions at the end of the operation, because if these have been made, there is a possibility of severe ulceration developing.

(4) *Dacryo-Cystorhinostomy* is an operation which aims at making a fistula between the lachrymal sac and the nose. There are various methods of performing this operation, and in capable hands satisfactory results are frequently obtained. The main difficulty is to prevent the

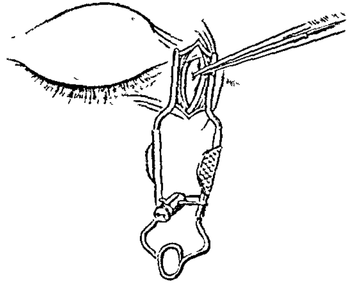


Fig 2455.—Removal of lachrymal sac The sac has been exposed and is in the grasp of a pair of forceps preparatory to being dissected out

opening in the bone from closing up, and this usually necessitates lining it with mucous membrane, an anastomosis being made between the wall of the sac and the nasal mucosa.

(5) *Excision of lachrymal gland.* In cases where the sac has been removed there is no channel for drainage of the tears, and troublesome watering of the eye is likely to occur, particularly when the patient is out of doors. In such cases relief may be obtained by removal of the palpebral portion of the lachrymal gland. In order to effect this, the eye is cocainised and a little novocaine and adrenalin is injected under the conjunctiva of the upper fornix near the outer canthus. The lid is everted and the tarsal cartilage gripped with a pair of forceps, these being turned so as to expose the conjunctiva of the fornix. An incision is made through this for a distance of about 1 cm. towards the outer

canthus. The lobules of the gland will then protrude through the wound as soon as the connective tissue is opened. A little dissection of the conjunctiva will then allow the palpebral lobe of the gland to be removed. A catgut suture is inserted to secure apposition of the conjunctiva.

OPERATIONS UPON THE CONJUNCTIVA

(1) *Formation of flaps.* These are required when dealing with wounds of the cornea, and may be fashioned according to the exigencies of the case. A simple and satisfactory form of flap may be obtained by incising the conjunctiva round the circumference of the cornea and separating it from the underlying sclera by blunt dissection with scissors. It is then brought together by a purse-string suture, and in this way the entire cornea can be covered and supported (figs. 2456 and 2457). The stitch usually cuts out after a few days and the conjunctiva retracts.

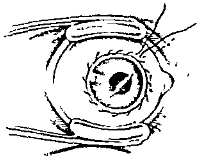


Fig 2456.—Purse-string suture inserted to bring conjunctiva over wound of cornea.

(2) *For pterygium.* The pterygium is grasped at its neck with a pair of fixation forceps, transfixed with a fine Graefe knife, and so separated from the cornea (fig. 2458). Care should be taken to remove only the head of the pterygium and not any of the substantia propria of the cornea. An incision is made with scissors through the conjunctiva along the lower margin of the pterygium, which is loosened from the underlying sclera, the conjunctiva below the incision being also well undermined. A double-armed silk suture is passed through the apex of the pterygium, the needles being carried downwards through the lower conjunctival incision so as to emerge in the 6 o'clock position about 4 mm. from the corneal margin (fig. 2459). Traction on the suture will draw the pterygium beneath the loosened conjunctiva, and at the same time close the conjunctival wound, so that when it is tied there is no need to insert additional stitches.

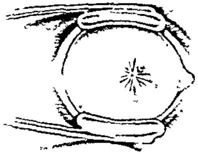


Fig. 2457.—Purse-string suture tied, and cornea completely covered by conjunctiva.

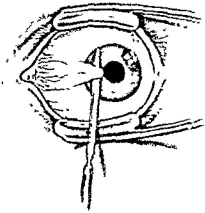


Fig. 2458.—Pterygium transfixed with Graefe knife.

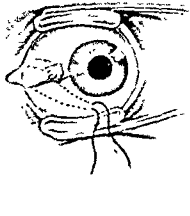


Fig. 2459.—Pterygium with suture inserted. Subconjunctival path shown by dotted lines.

(3) *Peritomy.* This operation is sometimes performed to bring about clearing of the cornea, and the disappearance of vessels in cases of old and recurrent ulceration and of pannus following trachoma. The conjunctiva is divided along a circular incision concentric with, but about 3 mm. outside, the corneal margin, and the 3-mm. band of conjunctiva is removed, subjacent vessels being divided as far as possible.

OPERATIONS UPON THE CORNEA

(1) *Application of Cautery.* This is sometimes required in cases of severe ulceration, particularly when carbolising has failed to bring about healing. The operation is performed under cocaine anæsthesia; if the patient is particularly nervous and requires a general anæsthetic, ether should, of course, be avoided. The cautery is applied at a dull red heat over the ulcerated area which can be demarcated by previous instillations of fluorescein. Care must be taken to do no more than touch the surface of the cornea, so as to produce as thin a scar as possible.

The cautery is also used in the operation for conical cornea (see page 4577).

(2) *Paracentesis* may be required in cases of corneal ulcer where perforation is imminent or where there is extreme pain. It is also employed as a last resort in cases of iritis with raised tension. The incision is best made with a " broad needle " at a point 1–2 mm. inside the lower margin in the cornea. The blade is entered in the plane of the iris, but directly the point is seen to have perforated, its direction is changed, so that it lies against the back of the cornea and thus avoids injury to the lens. The instrument is pushed on until the incision is sufficiently long, when it is carefully withdrawn, so as to prevent sudden escape of aqueous. Gentle pressure with an iris repositor on the peripheral lip of the wound will allow the aqueous to drain away slowly. This procedure can be repeated on the following days if necessary. A possible complication of the operation is prolapse of the iris, and the surgeon must be prepared to deal with this by iridectomy.

(3) *Guthrie's Section.* This operation, originated by Guthrie and subsequently advocated by Saemisch, may be the means of saving an eye which would otherwise have to be removed on account of severe and intractable ulceration of the cornea. Considerable pain is felt if the operation is performed under cocaine, so that it is best to employ a general anæsthetic or to infiltrate Tenon's capsule with novocaine. The incision is made with a Graefe knife with the cutting edge forwards, the point being inserted in healthy cornea just outside the edge of the

ulcer. The knife is carried across the anterior chamber until the point is beyond the far edge of the ulcer when the counter-puncture is made. The operator then cuts forwards through the floor of the ulcerated area. Atropine is instilled and a pad and bandage are applied to the eye.

This operation allows the escape of purulent aqueous and the drainage of exudate from between the infected layers of the cornea. In favourable cases, when healing occurs, only a fine linear scar remains to show that the operation has been performed.

(4) *Conical Cornea.* In a certain proportion of cases, the optical defects produced by this condition may be overcome by the wearing of a contact lens. Not all patients can tolerate this, however, and, in such, vision may be materially improved by surgical measures designed to bring about flattening of the apex of the cone. Of the many described, one of the simplest and most satisfactory is the following: The actual cautery is applied to a circular area of the cornea about 2·5 mm. in diameter with the apex of the cone at its centre. The peripheral portions are cauterised lightly, the central more deeply, perforation being allowed to occur at the central point of the circular area. After healing has occurred, a central cicatrix results which may be tattooed or stained with gold chloride, vision being obtained through the clear peripheral cornea by means of an optical iridectomy (see page 4580).

(5) *Corneal Grafting.* It is now possible, owing to the work of Tudor Thomas, to mitigate the blindness produced by opacity of the cornea. The performance of the operation calls for a considerable degree of skill and experience, and the cases require careful selection. The principles of the operation are briefly as follows:

The donor eye with a clear cornea is usually one which is being removed for sarcoma of the choroid. Immediately after the enucleation it is placed on a special stand and, with a 4·5 mm. trephine, aided by scissors, a disc of clear tissue is removed from the centre of the cornea. By tilting the trephine and completing the excision of the disc with the scissors, it is possible to cut it with shelving edges so that the anterior surface is wider than the posterior. The hole in the opaque cornea is cut in a similar manner with shelving edges, but is made slightly larger than the graft by employing a trephine of $4\frac{3}{4}$ mm. in diameter. The graft is then transferred to the opening made for it, and kept in place by sutures which pass over it and have their bight in the opaque cornea.

OPERATIONS UPON THE IRIS

The majority are performed under cocaine anæsthesia, but even so it is not always possible to anæsthetise the iris completely, while

if the eye is at all red cocaine instillation has practically no effect on the iris and general or infiltration anæsthesia is indicated.

Iridectomy. The technique of this operation varies according to the condition for which it is employed.

(1) In *congestive glaucoma* it is important to remove a wide segment of iris at its root. The incision is therefore placed as peripherally as possible, and is best made with a Graefe knife so as to avoid the possibility of injuring the lens. The point of the knife enters the sclera about 4 mm. to the temporal side of the 12 o'clock position (fig. 2460) and 1·5 mm. from the corneo-scleral margin. It is passed approximately parallel to the plane of the iris, and when the point is seen in the angle of the anterior chamber it is gently edged round so as

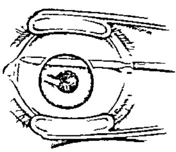


Fig 2460.—Iridectomy in congestive glaucoma. Puncture and counter-puncture have been made.

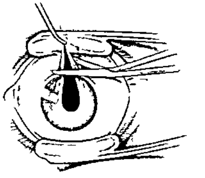


Fig 2461.—Iridectomy for congestive glaucoma. Abscission of iris.

to make a counter-puncture about 8 mm. distant from the puncture and 1·5 mm. behind the corneo-scleral margin. The section is completed by a gentle sawing movement, a conjunctival flap being obtained by turning the edge of the knife backwards after the sclera has been cut through. Iris forceps are introduced closed into the wound, and then opened so as to grasp the iris near the upper margin of the pupil. The iris is drawn outwards and a little nasally, the iris scissors (de Wecker's) being held in the other hand at the temporal end of the wound, with their blades pointing to the nose, parallel with and as close to the sclera as possible (fig. 2461). After the temporal half of the iris fold has been cut through, the direction of pull of the forceps is altered to the temporal side, and the nasal half of the fold is cut. By altering the direction of pull on the iris in this manner, its impaction in the angles of the scleral wound is avoided. After removal of the iris the margins of the gap (coloboma) are gently stroked back into position by

an iris repositor (fig. 2462), the conjunctival flap replaced into position, and the eye closed after instillation of atropine, a pad and bandage being applied. The risks of this operation—intra-ocular hæmorrhage and dislocation of the lens—are greater in proportion to the height of the intra-ocular pressure. If this is at all great, as shown by the presence of corneal opacity, it is advisable to perform posterior sclerotomy some five minutes before proceeding to iridectomy. To do this operation the eyeball is turned upwards and inwards, and the sclera with its overlying conjunctiva is punctured with a Graefe knife at a point 8 mm. from the corneal margin, midway between the exterior and inferior recti (fig. 2463). The knife, with cutting edge forward, should

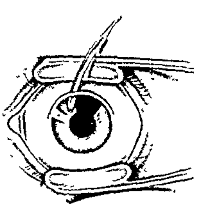


Fig. 2462.—Iridectomy for acute glaucoma. Reposition of pillars of coloboma.

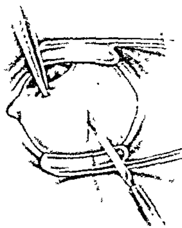


Fig. 2463.—Posterior sclerotomy. Graefe knife introduced with point directed towards centre of eyeball.

be pointed to the centre of the eyeball and introduced to a depth of 4–6 mm., being given a quarter turn during withdrawal. The effect of this manœuvre is to allow the escape of a bead of vitreous. This decreases the intra-ocular pressure, and at the same time permits the iris to fall back and deepen the anterior chamber, thus facilitating the subsequent iridectomy.

(2) *Iridectomy in old Iritis.* In these cases the eye is not usually inflamed, and cocaine anæsthesia suffices for the operation. A smaller portion of iris is removed, so that the incision can be made with a keratome (see fig. 2464), which leaves a neat, small linear scar. With the patient looking down, the point of the instrument is made to penetrate the eye about 1 mm. behind the limbus in the 12 o'clock position. It is held so that the blade makes an angle of 45 degrees with the sclera, but directly the point of the instrument is seen in the eye, the direction of

the knife is changed so as to make it lie in the plane of the iris, and thus avoid injuring the lens. It is then pushed steadily onwards, until an incision of the desired length (about 5 mm.) is made, or, alternatively, it is not pushed so far but is made to cut outwards to the temporal side on withdrawal. This part of the operation should be performed with care, and as little aqueous allowed to escape as possible, otherwise the lens may be injured. Iris forceps are introduced closed into the wound, and then opened and made to draw out a fold of iris, which is cut with the iris scissors held so that their blades are at right angles to the

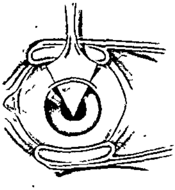


Fig. 2464.—IRIDECTOMY. INCISION WITH KERATOME.

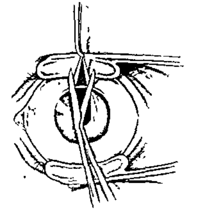


Fig. 2465.—IRIDECTOMY. ABSCISSION OF THE IRIS.

incision in the sclera (fig. 2465). The pillars of the coloboma are then stroked back into position with an iris repositor.

Optical Iridectomy. The technique of this procedure is not quite the same. The object of the operation is to alter the position of the pupil, and the site of election is downwards and inwards, as this gives the best optical result, though often the iridectomy has to be made elsewhere—behind whatever portion of cornea remains clear. As the periphery of the iris has to be preserved, the incision is made in the limbus or even slightly inside it. Subsequent steps are as already described. Iridectomy as part of cataract extraction is described later.

OPERATIONS UPON THE LENS

Cataract extraction can nearly always be performed under cocaine anæsthesia. It is rendered easier if the pupil is dilated with cocaine and homatropine. The operator stands or sits behind the patient's head, inserts a speculum, and grasps the conjunctiva with fixation forceps, just below the nasal end of the horizontal meridian of the cornea. He makes the incision with a Graefe knife which is introduced from the temporal side of the eye. The right hand is there-

fore used for the right eye, and the left hand for the left eye. The knife, with its edge towards the operator, pierces the corneo-scleral margin at a point 1 mm. above the end of the horizontal diameter, and is carried straight across the anterior chamber, to emerge at a corresponding point in the limbus on the opposite side (fig. 2466). In order to effect this, the knife must be directed to a point in the cornea, 1 mm. inside the limbus, as otherwise it may emerge through the sclera, and troublesome hæmorrhage result. As soon as the counter-puncture is made, the knife is carried steadily upwards, parallel to the plane of the iris, and the incision in the limbus completed with two or three sawing movements. A good flap of conjunctiva can easily be secured by not cutting out through this membrane too soon after the corneo-scleral incision has been completed. The flap is now turned down and

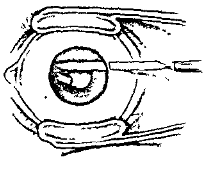


Fig 2466.—Cataract extraction. Puncture made. Graefe knife has picked up a little conjunctiva but is penetrating corneo-sclera at the limbus, and is almost in position to make counter-puncture.

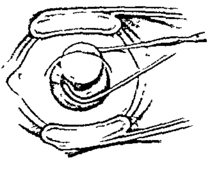


Fig 2467.—Cataract extraction. Expression of the lens.

a cystitome introduced, with which a horizontal incision is made through the anterior lens capsule. Some operators effect this with the point of the Graefe knife during its passage across the anterior chamber, in which case a cystitome need not be used.

The lens has now to be expressed. If the right eye is being operated upon, the surgeon takes a squint hook in the right hand, and a cystitome and curette in the left hand. The squint hook is pressed gently backwards over the lower margin of the cornea, while the curette is used to make the wound gape by pressing on the sclera forming its posterior margin, and as a result of these manœuvres the edge of the lens soon presents in the wound (fig. 2467). When this occurs, the instrument in the left hand is reversed, and the cystitome, with the plane of the blade facing the surgeon, is thrust into the lens which can then be lifted out of the eye, its lower edge being followed up with the squint hook,

moments the upper lid may be gently raised, and if the patient will look down, an attempt is made to replace the iris with a repositor. If this is not possible, the eye should be closed and a dressing applied, prolapsed iris being removed under infiltration or general anæsthesia a few days later.

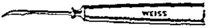
(4) *Intra-ocular hæmorrhage.* This may occur at the end of an apparently successful operation. The patient usually complains of pain, the wound slowly opens, and a large bead of vitreous appears. The only hope of saving the eye lies in the immediate application of a pad and a firm bandage. Unfortunately, however, the hæmorrhage usually continues in spite of this, forcing the vitreous, and sometimes even the retina, into the wound, so that the eye has to be excised.

(5) *Prolapse of iris.* At the conclusion of the operation it may be found that the iris will not go back easily into the eye, or that having been reposed it shows a tendency to come out again. In such cases it is wise to perform peripheral iridectomy by picking up a small fold of iris near its root and snipping it off with iris scissors, the blades being held tangentially to the limbus. In other cases it is necessary to perform a complete iridectomy. If the prolapse does not occur till later, it should be dealt with by abscission after infiltration of Tenon's capsule with novocaine, because it is almost impossible to render the exposed iris insensitive, even by the application of solid cocaine. In a fair proportion of these cases, even though the prolapsed iris is removed, the pupil becomes displaced so far upwards that the eye is useless for purposes of vision (see fig. 2468), and the operation of *iridotomy* is required. This consists in making a slit in the iris, so that a gap is formed in the position normally occupied by the pupil. A similar complication sometimes follows retroversion of the iris, in which the upper portion of the iris becomes folded back over the ciliary body.

(6) *Detachment of the choroid.* This complication probably occurs in about 90 per cent of operations for cataract or glaucoma. In the majority of cases the detachment is only slight in degree, and as the choroid becomes reposed in the course of a few days, it is not noticed. In others, however, particularly if there is delayed closure of the wound so that the anterior chamber does not re-form, the detachment is bigger and can be seen with the ophthalmoscope as a dark, almost black, area, obscuring part of the fundus. The condition is seldom of any clinical importance, though in the first case in which it was noticed the eye was excised because it was thought to contain a choroidal sarcoma. It disappears after a variable period when healing of the wound has become complete, and leaves no ill-effects behind it.

(7) *Post-operative iritis.* A mild degree of this probably occurs in all cases of cataract extraction, but if adequate pre-operative precautions have been taken it should be only slight. Should the iritis be severe, it means that some source of infection, either local or general, has been overlooked, and a painstaking examination of the patient is called for, subsequent treatment being based on the findings. Locally, the eye should be treated on the lines already laid down for

Fig 2469.—Ziegler knife-needle.



Iritis, while if the iritis continues for longer than three or four weeks, it may have to be excised on account of the danger of sympathetic ophthalmia in the fellow eye.

Needling or discission. In patients under the age of thirty, a cataractous lens is usually soft enough to be removable by the solvent action of the aqueous, provided this fluid is given access to the lens fibres. This is afforded by the following operation (Ziegler's method): After cocainisation and dilatation of the pupil (in small children, a general

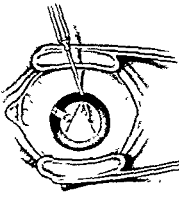


Fig. 2470.—Needling by Ziegler's method.

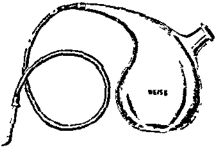


Fig. 2471.—Irrigating cannula.

anæsthetic is required), a speculum is inserted and the patient directed to look down. The eye is steadied with fixation forceps which grasp the conjunctiva below, and a Ziegler knife-needle (fig. 2469) is inserted on the flat inside the limbus at 12 o'clock (fig. 2470). The point is carried downwards until it is just under the edge of the dilated pupil, at 4.30 o'clock, when the handle is raised and rotated so that the point is made to enter the lens and pass through its entire thickness. By withdrawing and raising the handle of the knife-needle, its blade is made to cut through the whole thickness of the lens along a line from 4.30 to 12 o'clock. The procedure is then repeated, so as to make a linear

is usually turned down over the cornea and kept stretched by an iris repositor laid horizontally upon it, but it is sometimes easier to hit off the right plane for dissection if the flap is laid back on the sclera with the Tooke knife deep to it, and clearly visible through the translucent tissues (fig. 2473). When this part of the operation has been successfully performed, the so-called "dark crescent" of cornea can be clearly seen. With the flap drawn forwards, the trephine, held between the thumb and the forefinger, is applied close to it, so as to make the *hole in the corneo-sclera as far forward as possible without actually* buttonholing the flap. The trephine should be sloped a little to the temporal side, and gently rotated until it has cut out a disc of corneo-sclera. When this occurs, the patient usually feels a little pain owing to contact

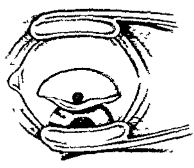


Fig. 2472.—Sclero-corneal trephining. Flap is drawn back to show position of hole at limbus and so covers the peripheral iridectomy.

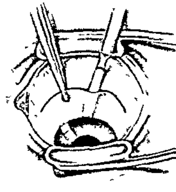


Fig 2473.—Splitting the cornea with Tooke's knife held deep to the conjunctival flap.

between the trephine and the iris, and the pupil, unless bound down, becomes oval in an upward direction. The assistant must be on the watch for this, otherwise the trephine may pass into the eye and wound the lens. *The trephine is now removed, and the disc is seen, attached* by a narrow hinge of sclera on its inner side and pushed upwards by a black bead of prolapsed iris. This and the disc are grasped by a pair of iris forceps or Elliot disc forceps, and cut off with a pair of de Wecker scissors held with the blades tangential to the limbus. The result is to remove the disc and produce a small V-shaped peripheral gap in the iris. Some surgeons prefer to perform these two operations separately, *the iris usually being removed first, because of its liability* to slip back into the eye.

If the pupil is not quite round, the iris is smoothed back into place by stroking the cornea gently with an iris repositor, after which the

incision from 7.30 to 12 o'clock, and thus produce a wide inverted V (fig. 2470). In favourable cases, the lens matter will gradually dissolve, and in the course of one to three months a clear pupil will be left. In others, secondary glaucoma will develop owing to the aqueous being rendered viscous by dissolving lens matter. In these cases it is necessary to make a keratome incision at 12 o'clock, about 5 mm. long and ½ mm. behind the limbus. An irrigating cannula (see fig. 2471) is introduced through this and the remnants of lens matter are washed out with sterile normal saline at body temperature. This procedure may also be required in cases where it is desired to hasten the clearing of the pupil or where there is undue delay in solution of the lens matter.

The operation of discission is also required when a membrane or lens matter remains in the pupil after cataract extraction. In these cases, the needle is made to enter the eye at the limbus on the temporal side, the point being carried slightly beyond the centre of the pupil before it engages the membrane. The direction of the incision is varied to suit the requirements of the case, thus it should be horizontal if the membrane appears to be specially tense in the vertical direction, so that the edges will gape well. This operation should not be performed until at least six weeks after the original extraction, otherwise the wound may re-open. Some membranes are very tough and, if it is impossible to secure an adequate opening, may have to be removed by forceps through a keratome incision.

OPERATIONS FOR GLAUCOMA

The operations of iridectomy and of posterior sclerotomy have already been described. Trephining is performed, under cocaine anæsthesia, as follows:

A speculum is inserted, preferably the type with solid blades (Lister's) which cover the eyelashes, and the patient is directed to look down. A fold of conjunctiva is picked up with fixation forceps about 8 mm. above 12 o'clock on the limbus, and a large flap made, the margin of which is almost concentric with the cornea (fig. 2472). The flap is dissected up with scissors, care being taken to make it as thick as possible. When the corneal margin at 12 o'clock is reached, the surgeon takes a Tooke knife and carefully splits the cornea for a further millimetre. It is important to work at exactly the right place, i.e. just in the plane of the conjunctival flap. If the knife is placed too far forwards, the conjunctiva is buttonholed; if too far back, all that happens is an ineffectual scratching of the sclera. The flap at this stage

is usually turned down over the cornea and kept stretched by an iris repositor laid horizontally upon it, but it is sometimes easier to hit off the right plane for dissection if the flap is laid back on the sclera with the Tooke knife deep to it, and clearly visible through the translucent tissues (fig. 2473). When this part of the operation has been successfully performed, the so-called "dark crescent" of cornea can be clearly seen. With the flap drawn forwards, the trephine, held between the thumb and the forefinger, is applied close to it, so as to make the hole in the corneo-sclera as far forward as possible without actually buttonholing the flap. The trephine should be sloped a little to the temporal side, and *gently rotated until it has cut out a disc of corneo-sclera.* When this occurs, the patient usually feels a little pain owing to contact

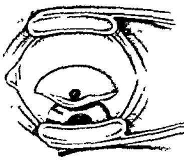


Fig. 2472.—Sclero-corneal trephining. Flap is drawn back to show position of hole at limbus and so covers the peripheral iridectomy.

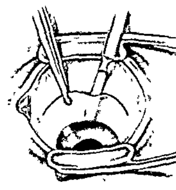


Fig. 2473.—Splitting the cornea with Tooke's knife held deep to the conjunctival flap.

between the trephine and the iris, and the pupil, unless bound down, becomes oval in an upward direction. The assistant must be on the watch for this, otherwise the trephine may pass into the eye and wound the lens. The trephine is now removed, and the disc is seen, attached by a narrow hinge of sclera on its inner side and pushed upwards by a black bead of prolapsed iris. This and the disc are grasped by a pair *of iris forceps or Elliot disc forceps, and cut off* with a pair of de Weeker scissors held with the blades tangential to the limbus. The result is to remove the disc and produce a small V-shaped peripheral *gap in the iris. Some surgeons prefer to perform these two operations* separately, the iris usually being removed first, because of its liability to slip back into the eye.

If the pupil is not quite round, the iris is smoothed back into place by stroking the cornea gently with an iris repositor, after which the

conjunctival flap is reposed and secured in place with one or two sutures. Atropine is then instilled and both eyes covered, the after-treatment being the same as for a cataract operation.

DIFFICULTIES AND COMPLICATIONS

(1) *Buttonholing the conjunctival flap.* This may occur at the time that the cornea is being split, or the hole may be cut when using the trephine owing to its being placed too far forwards. *In the first case, the flap* should be extended laterally so as to allow of the trephine hole being covered by intact conjunctiva. In the second case, the following procedure (von Mende) should be carried out:

Extend the buttonhole about 2 mm. towards the nasal side and 8 mm. towards the temporal side by cutting round the limbus with scissors, and

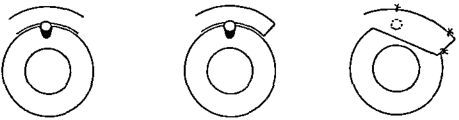


Fig 2474.—VON MENDE'S OPERATION.

(*a*) Upper and lower margins of flap outlined by extending "buttonhole"
(*b*) Flap completed
(*c*) Flap sutured in position so as to cover trephine hole (indicated by dotted line).

outline a flap (fig. 2474 *a*). This should now be mobilised and attached to the sclera with sutures as shown in fig. 2474, *b* and *c*, thus providing a covering to the trephine hole.

(2) *Failure of the iris to prolapse.* This is usually due to the cornea not having been split far enough forwards. An attempt to pick out the iris with forceps may result in damage to the lens and subsequent traumatic cataract, so it is best left alone. Should the iris prolapse subsequently, it can easily be removed after reflecting the conjunctival flap.

(3) *The disc goes into the anterior chamber.* Should the disc be cut out quite cleanly and fall to the bottom of the anterior chamber, it can be left and will do no harm. If, however, as more commonly happens, it is still attached to the edge of the hole by a few strands of sclera, the disc may swing back into position again after the operation and block it. Some operators advise leaving the disc even under these circumstances, but it is usually possible to bring it outside the eye by careful manipulation with a Tyrell hook.

(4) *Closure of the trephine hole.* In a certain proportion of cases drainage never becomes properly established, or, after having existed

for a short time, it ceases owing to the trephine hole healing over. This is usually due to the cornea not having been properly split at the time of operation, so that the trephine was placed wholly on the sclera and not overlapping the cornea. Its occurrence necessitates the performance of another operation over a different portion of the corneo-sclera. If the second hole closes and the operation has to be performed a third time, it may be advisable to use a trephine of 2-mm. diameter instead of the usual $1\frac{1}{2}$ mm.

(5) *Delayed formation of the anterior chamber.* This is seldom a cause of anxiety though it may be a matter of weeks before the chamber is properly formed and there may be a large detachment of the choroid. Occasionally, however, it never forms, the lens becomes opaque, and vision is lost.

DETACHMENT OF THE RETINA (see also page 4544)

The first essential is accurate localisation of the hole or holes in the retina. The overlying sclera is then exposed and subjected to diathermy with a special type of instrument. The effect of this is to produce a traumatic inflammation in the subjacent choroid, so that when the sub-retinal fluid is let out by puncture of the sclera, the margins of the retinal hole become adherent to the choroid, and the hole is completely blocked.

SQUINT OPERATIONS

These are usually performed in cases of concomitant squint (see page 4562), though occasionally paralytic cases are benefited by surgical interference if the condition has persisted for over a year and general treatment has been of no avail. The majority of concomitant squints are convergent, and the operations consist in:

(1) Weakening or lengthening the internal rectus.
(2) Shortening or "advancing" the external rectus.

In some cases, both these procedures are carried out at the same time, so as to increase the amount of correction obtainable. The degree to which one or other operation is to preponderate should be carefully worked out beforehand. If the angle of the squint is greater in distant vision than in near vision (divergence insufficiency), the strengthening of the external rectus should be greater than the weakening of the internal rectus, whereas in the converse condition (convergence excess), the internal rectus effect should be the more marked.

Opinions vary as to whether these operations should be carried out under local or general anæsthesia, but the author's preference is in favour of a general anæsthetic.

OPERATIONS TO WEAKEN THE INTERNAL RECTUS

(1) *Tenotomy* (fig. 2475). A vertical incision, 5–7 mm. long, is made through the conjunctiva about 4 mm. to the nasal side of the limbus. This is best done with scissors which are then used to dissect up the nasal margin of the wound for a short distance. This allows the episcleral tissue and Tenon's capsule below the tendon of the internal rectus to be snipped through so that a squint hook can be introduced between the tendon and the globe. Scissors are now passed along in front of the hook, and the tendon is severed as close to the globe as possible. A small squint hook is then passed into the wound and moved up and down to determine whether all the tendon fibres have

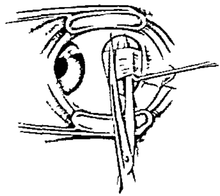


Fig 2475.—Tenotomy of right internal rectus.

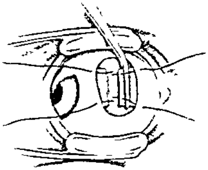


Fig 2476.—Recession of right internal rectus showing sutures.

been divided; if any are found they must, of course, be cut through. The operation is completed by uniting the conjunctiva with one or two sutures. It usually produces 10–15 degrees of correction, but even in experienced hands the result is variable, and in a few years' time the eye may become widely divergent owing to slipping back of the muscle. This difficulty can be overcome by stitching the muscle to the sclera when the operation is known as:

(2) *Recession* The tendon is exposed as before, but the conjunctival incision should be almost at the semilunar fold, and the muscle grasped in Prince forceps before it is severed from the globe, the forceps being placed some 2 mm or so from the line of section. Double-armed sutures are used of No. 1 silk, about 7 inches long, and of the type in which the silk is fixed in the end of a small curved needle. The point of this is placed on the eye in line with the upper end of the cut tendon, and at a predetermined distance from it, which

is best measured by calipers. The needle is passed vertically downwards, so as to pick up a few fibres of sclera. It is carried on so as to penetrate the muscle from behind forwards at a point just below its upper margin and in front of the Prince forceps, and brought out through the conjunctiva forming the nasal margin of the wound. The other needle is made to come out through the conjunctiva, forming the temporal side of the wound (fig. 2476). A second stitch is passed in a similar manner, but in line with the lower end of the tendon. When these stitches are tied, the conjunctival wound is closed, and the tendon is anchored to the sclera at the point where the stitches have been passed. This point, as already mentioned, is determined before the operation, and the following table (quoted from Wilkinson) affords a guide as to how far the tendon should be put back:

Recession of	3	mm.	will correct	11	degrees of	squint.
,,	4	,,	,, ,,	15	,,	,,
,,	5	,,	,, ,,	19	,,	,,

If the muscle is put back more than 5 mm. there is a risk of divergence of the eye later.

OPERATIONS ON THE EXTERNAL RECTUS

(1) *Resection.* The muscle is exposed by a vertical incision in the conjunctiva over its insertion, i.e. 7 mm. to the temporal side of the limbus. It is freed from surrounding tissues and grasped in Prince forceps, and its tendon is cut through 1·5 mm. from its insertion, thus leaving a stump of this length attached to the eyeball. A double-armed No. 1 silk suture is now taken and both needles are passed through

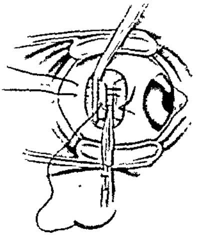


Fig. 2477.—Recession of right external rectus. Upper suture inserted, upper needle of lower suture passing through stump of external rectus.

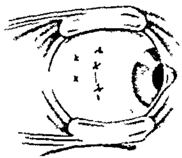


Fig. 2478.—Sutures tied. Conjunctival wound closed with three superficial stitches.

it is likely to become extruded later. The conjunctiva is united by interrupted silk sutures.

The advantage of this operation is twofold:

(1) The glass eye has better movement.

(2) Being supported from behind, it does not sink back into the orbit, and the lids are kept more widely apart.

A third variant of enucleation is Mules' operation. Here the conjunctiva is divided and separated from the sclera as before, but the muscles are left intact. The cornea is removed by an incision round the limbus which extends a little into the sclera at each end of the horizontal meridian. The contents of the eye are eviscerated, Mules' scoop being a convenient instrument for the purpose. Care must be taken to remove everything down to the sclera and not to leave fragments of uveal tissue. After hæmorrhage has been checked, a glass ball of suitable size is inserted and the sclera united in the horizontal meridian by sutures of strong white silk. The conjunctiva is then brought together in the vertical meridian by means of interrupted black silk sutures which are removed at the end of a week.

There is usually a considerable reaction with swelling of the lids for the first few days. After successful performance of this operation, the mobility of the glass eye may be so good as to deceive even an experienced observer Unfortunately, however, its application is limited to cases where:

(1) There is no risk of sympathetic ophthalmitis.

(2) There is no question of the eye containing a neoplasm.

(3) The interior of the eyeball is not grossly infected (panophthalmitis). Should this be the case, simple evisceration may be performed. The cosmetic effect of this is often surprisingly good, the procedure being the same as Mules' operation except that no glass ball is inserted, the conjunctiva is not separated from the sclera, and the edges of the latter are not united.

Exenteration is required in some cases of malignant disease of the orbit. If the lids are not involved in the growth, they may be retained, but the free margins carrying the lashes should always be removed. The outer canthus is divided with scissors, so as to expose the outer border of the orbit, and the conjunctiva of the lower fornix is then cut through with a sharp scalpel so as to expose the lower border of the orbit, the upper being exposed by a similar incision through the conjunctiva of the superior fornix. These incisions meet on the inner side, over the front part of the lachrymal bone. Both lids can now be easily drawn apart with tenacula, allowing the entire orbital border to be

exposed, and an incision made round it through the periosteum. By means of a periosteal elevator or closed slightly curved scissors pushed between the bone and the periosteum, the orbital contents can be shelled out as far as the apex. The mass is then removed as far back as possible by a few snips of the scissors. Hæmorrhage can usually be checked by tamponing, though sometimes a cautery may be required.

The cavity thus left takes a long time to granulate, and a better result is obtained if it be skin grafted. For this purpose a Stent mould is made of the orbit, and round it is wrapped a Thiersch graft of suitable size with the raw surface outwards (Gillies). The graft is best taken from the inner surface of the thigh, where a sufficiently large area of hairless skin can be obtained. It is inserted into the orbit, wrapped round the mould at the conclusion of the operation, and is kept in place

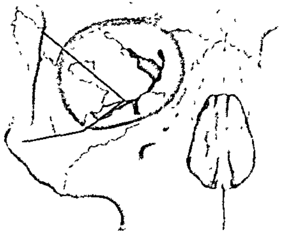


Fig. 2479.—Krönlein's operation, to show the lines along which the bone is divided.

by the dressing. If the skin of the lids is to be used to cover the anterior part of the orbit, they should be split so as to allow removal of the tarsal cartilages and conjunctiva. The lash-bearing margins should, of course, also be removed.

Krönlein's operation provides a means of removing an orbital tumour while leaving the eye *in situ*. The incision, 7 cms. long in an adult, starts at a point about half an inch above the external angular process of the frontal bone, curves forwards to bisect a horizontal line joining the outer canthus and outer orbital margin, and then backwards, to terminate at the middle of the zygoma. The central part of this incision goes down to the bone so as to expose the orbital margin and allow the introduction of an elevator with which the periosteum is separated from the outer wall of the orbit. The contents of the latter are held away with a spatula, and the spheno-maxillary fissure is

located and marked with the elevator. An incision through the bone is then made with a chisel or electric saw from a point a little above the external angular process of the frontal bone to the anterior end of the fissure, and a second one from the base of the orbital process of the malar bone backwards to the same point (see fig. 2479). A wedge-shaped portion of bone has thus been resected and can be swung outwards, exposing the periosteum which lines the lateral wall of the orbit. This is incised with scissors from before backwards, so that the contents of the orbit can be explored. If freer access is required, the external rectus can be divided between catgut sutures which are used to reunite it at the end of the operation. After removal of the tumour and arrest of hæmorrhage, the bone is swung back into place, the periosteum united with catgut sutures and the skin incision sewn up in the usual manner.

If the tumour be located in the anterior part of the orbit, a less extensive procedure may suffice for its removal. A skin incision is made from the supra-orbital notch to the temporal side of the orbit parallel to its upper margin. The periosteum can then be stripped off the bone and the orbital contents depressed sufficiently to leave room for surgical manipulations.

PART XXV

EAR

by

F. W. WATKYN-THOMAS

CHAPTER I
Examination of the Ear

CHAPTER II
Surgical Conditions of the Auricle and External Auditory Meatus

CHAPTER III
Acute Surgical Conditions of the Middle Ear and Mastoid

CHAPTER IV
Surgery of Chronic Suppurative Otitis Media: *Surgery of the Labyrinth; Intra-cranial Complications*

EAR

CHAPTER I

Examination of the Ear

I. *Case History*

The points of particular importance are:

(1) Nature of onset: whether with deafness, tinnitus, pain, or feeling of "congestion" or "tightness."

(2) Nature of discharge, if any: whether sero-sanguineous, mucoid or purulent.

(3) Condition prior to onset: coryza, "influenza," other acute infections, previous trouble with either ear.

(4) Pain, headache or vertigo.

II. *General Inspection*

(1) A first observation will show the position of the head. Torticollis suggests irritation of the sterno-mastoid either by deep abscess (Bezold's mastoiditis) or by inflamed glands. Rotation of the head suggests labyrinthine or intra-cranial complications. Retraction or rigidity suggests meningeal irritation. Facial weakness on either side, and any squint or nystagmus should be noted.

(2) The relation of the affected ear to the side of the head should be compared with that of the sound one. Is the position unaltered, or is the ear pushed outwards, forwards or downwards? This inspection should be made from in front and behind; from behind we shall see whether the retro-auricular sulcus shows clearly.

(3) Is there any swelling?

(*a*) In front of the ear (e.g. of the pre-auricular gland or of the parotid).

(*b*) Above the ear (e.g. in the temporal or zygomatic regions).

(*c*) Behind the ear (e.g. of the mastoid itself or of the mastoid lymphatic glands).

(*d*) Below the ear (e.g. of the sterno-mastoid muscle or of the cervical lymphatic glands).

(4) Appearance of the auricle: whether normal or red and swollen; presence of discharge or eczema. Palpation for tenderness and œdema should be deferred until the rest of the examination is finished.

III. *Otoscopy*

Accurate knowledge of the normal and of the diseased appearances of the drum is best acquired by the use of the head mirror and reflected light, but for convenience at the bedside and in private houses, the electric otoscope (fig. 2481) has many advantages. The instrument should be simply and strongly made; it should

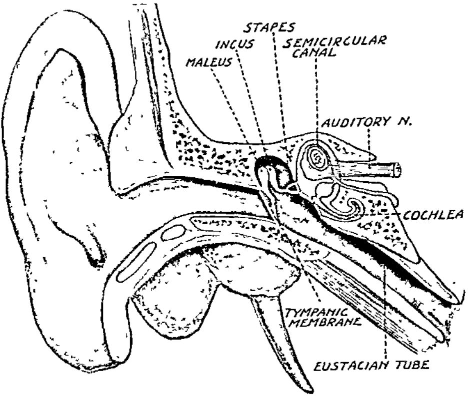


Fig 2480.—Sectional diagram of the auditory apparatus.

have a suction attachment ("Siegle's speculum") so that the pressure in the meatus can be altered under direct observation, and the air-tight lens-head should be replaceable at will by a small lens on a swivel which allows instruments to be passed into the meatus under magnification.

Some Practical Points in Otoscopy

(1) The speculum is straight and the soft meatus is bent. In order to straighten the meatus, the auricle should be drawn upwards, backwards and outwards. In infants and young children the meatus is not fully developed, so the auricle must be pulled *down* to give a view of the membrane; sometimes this infantile condition persists in the adult.

(2) A warmed speculum is often much appreciated by a patient with a sensitive meatus.

(3) Swellings and ulcers in the outer part of the meatus are best seen by the head mirror and reflected light without any speculum.

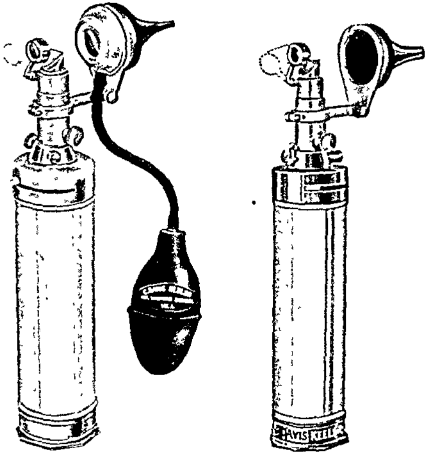


Fig. 2481.—Electric Otoscope.

(4) The universal rule of surgery holds good: the better ear should be examined first. This gives the patient confidence, and may give us information as to previous inflammations or anatomical peculiarities.

Removal of Cerumen, Debris and Pus

If an *electrical suction apparatus* is available, the simplest and safest way of clearing the meatus is by a Eustachian catheter, straightened out and attached to the suction tube. The nozzle of the catheter must be kept under direct observation and must not touch the meatal wall. This method is especially useful when cerumen is impacted in a tender and swollen meatus.

Syringing is the usual method, but the syringe must never be used: (1) If there is a history of injury to the ear (e.g. laceration

of the membrane or any possibility of a fracture of the basis cranii); (2) When severe pain suggests the possibility of an acute otitis media behind a mass of cerumen; (3) Within forty-eight hours of a perforation or incision of the membrane in acute otitis media; (4) When there is an old dry perforation or an attic perforation with retained cholesteatoma; (5) In acute eczema of the ear; and (6) In some cases of a foreign body in the meatus (see page 4611).

Practical Points in Syringing

(1) The all-metal "aural syringe" is clumsy and inefficient. It usually jams or leaks after a few weeks' use. It is far better to provide a large urethral syringe of the Record type.

(2) The water should be warm, about 98° F., otherwise irrigation may cause pain or vertigo. All air should be expelled from the syringe before starting the douching.

(3) The patient's head must be firmly supported lest a sudden involuntary movement should drive the nozzle against the meatal wall or the drum.

(4) Cerumen swells when wet; therefore, if we start syringing, the main mass must be removed, however difficult it may be, otherwise the swelling of the impacted cerumen may cause pain, or even damage the membrane.

When syringing is contra-indicated and no suction apparatus is available, pus and loose debris should be removed under direct vision with wisps of wool wrapped around a probe; cerumen can be extracted with a small spoon or right-angled hook passed gently along the meatal wall. If this is done, the greatest care must be taken to steady the patient's head, and the end of the instrument must be seen the whole time.

What must be done when the condition is too painful to allow adequate clearing of the meatus?

(1) If the pain is due to *swelling of the soft meatus* (e.g. in furunculosis), inspection of the drum is usually of secondary importance and harm will be done by untimely vigour. Treatment of the local condition must come first.

(2) But if the pain is *associated with impacted cerumen*, there must be no hesitation in giving an anæsthetic and removing the obstruction with instruments. It is a safe rule in such a case that the greater the difficulty in seeing the drum, the more likely it is that there is an acute inflammation and the more necessary it is to make sure.

Examination of the Meatus and Membrane

(1) *The Meatus.* Note any swelling or excoriation. A swelling in the wall of the bony meatus cannot be a furuncle, as furuncles arise in the pilo-sebaceous glands, which do not extend beyond the cartilaginous meatus. *A hard swelling in the wall of the deep meatus* is probably an exostosis, a *soft swelling* either periostitis, a subperiosteal abscess or (rarely) a cholesteatoma breaking through the posterior meatal wall. *Blood-blisters* suggest otitis externa hæmorrhagica (see page 4618) or (rarely) herpes (see page 4619). *Pouting granulations* on the posterior wall usually surround a fistula into the mastoid cells. *Polypi* should be unmistakable (but see page 4605), and remember that a dark, friable bleeding polypus may be malignant.

(2) *The Drum* (fig. 2482). The most constant landmark is the *short process of the malleus.* This is the last point to be submerged by a swell-

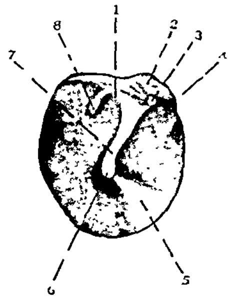


Fig 2482.—Normal tympanic membrane (Right.)
1. Posterior fold
2. Shrapnell's membrane
3. Short process of the malleus.
4. Anterior fold
5. Cone of light.
6. Umbo
7. Handle of malleus
8. Long process of the incus

ing drum, and survives the destruction of the rest of the tympanic contents by suppuration. Taking this as the "rallying point", the handle of the malleus can be traced down from it; the long process of the incus, articulating with the stapes, lies behind; immediately above it is Shrapnell's membrane, and above that the outer bony wall of the attic, in which are the head of the malleus and the body of the incus.

The margins of the tympanic membrane should be identified next, and any perforation or bulging can then be "sited" in relation to fixed landmarks. For convenience it is usual to adopt some arbitrary marking, either sub-dividing the drum into quadrants, or, better, using

the "clock-face" convention of the musketry instructor (figs. 2483 and 2484). *Bulging* of the drum may be confusing if it is so pronounced that the handle of the malleus and the attachment of the membrane are obliterated ; it is revealed by the loss of landmarks and the apparent continuity of the posterior wall and the membrane. *Pulsation* is easily detected. This is usually a sign of increased pressure in the tympanic cavity with escape of pus through an inadequate perforation of the drum. The appearance of a *hair line* across the drum surface, which

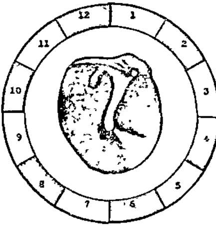


Fig. 2483.—Right tympanic membrane showing conventional "clock face" division.

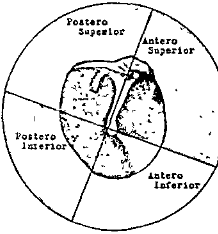


Fig. 2484.—Right tympanic membrane showing sub-division into quadrants.

remains horizontal whatever the position of the head, or of a shifting bubble, shows that the tympanic cavity is partially filled with fluid, which is usually serous or mucoid (catarrhal otitis media).

Common Mistakes

(1) There is a mistake which is so elementary that it seems incredible until one has actually made it. If the ear is not pulled out enough to straighten the curves of the soft meatus, the speculum points backwards and what is seen is the posterior part of the meatus and the adjoining meatal wall. The margin of the membrane may then be taken for the malleus, and the neighbouring meatal wall appears to be as a "red" or "opaque" posterior part of the membrane.

(2) Missing an attic perforation can be avoided by identifying the upper margin of the membrane and carefully inspecting the meatal wall and roof above it. An attic perforation is often hidden by a small crust of dried pus.

(3) Failing to recognise pus behind a pallid drum; this "pale bulge" is often missed, but it should be detected by the loss of landmarks and the altered curvature of the membrane.

(4) Mistaking a polypus blocking the bony meatus for a bulging drum. The sharply defined margin of the protrusion, its proximity to the surface, and its insensitivity to a probe establish the diagnosis.

(5) In infants, the drums often bulge when the child cries; this bulging is due to air, not to fluid.

(6) In some children and a few adults, the introduction of a speculum into the meatus causes a reflex congestion of the tympanic vessels. This transient flush must not be taken as a sign of inflammation.

Some Difficulties

The appearance of the drum in chronic non-suppurative deafness does not concern us from the surgical standpoint. It should be remembered that the *slope of the membrane* varies at different ages and in different individuals. In young children it is more nearly horizontal (25° inclination). "*Thickening*" *of the membrane* is an inaccurate term often used when *opacity* is meant; there is one real thickening of the membrane, and that is a pallid infiltration, which is usually due to pneumococcal infection. *Granulations* or *swollen mucosa* protruding through a perforation may be very puzzling. The true state of affairs is usually revealed by instilling a few drops of adrenalin.

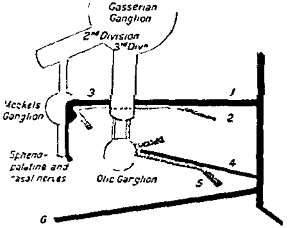


Fig 2485.—Diagram showing how pain can be referred to the ear from the regions of the Vth, IXth and Xth nerves, and from the sympathetic supply

(1) *Great superficial petrosal*
(2) Sympathetic fibres from carotid plexus
(3) Vidian
(4) Small superficial petrosal
(5) Branch of glosso-pharyngeal from petrous ganglion to otic ganglion and thence to the auriculo-temporal.
(6) Chorda tympani.
(7) Communicating branch to Arnold's nerve from vagus

(*From "Principles and Practice of Otology," Watkyn Thomas and Yates, H. K. Lewis*)

Pain referred to the ear from elsewhere is a common difficulty. If nothing can be found in the ear itself to account for the pain, the cause must be sought in the area connected with the geniculate ganglion (fig. 2485), or in the region of the inferior division of the trigeminal, from which the auriculo-temporal nerve is derived. The most common source of pain referred to the ear is a carious lower molar, especially an impacted wisdom tooth; after this in frequency come ulceration in the tonsil, pharynx or larynx, sphenoid suppuration, and extrinsic carcinoma of the larynx invading the pyriform fossa.

IV. *Examination of Hearing*

In surgical conditions of the ear, as distinguished from the various kinds of deafness without suppuration, quantitative estimation of hearing by standardised tuning forks or by the audiometer is of scientific rather than of practical value. The only exceptions are the cases, at present very rare, in which operative measures are attempted for the relief of otosclerosis (see page 4666).

For ordinary surgical purposes it is enough to know roughly:

(1) Whether the deafness is partial or complete:

(*a*) If partial, how much useful hearing remains ? and

(*b*) Is the deafness increasing or diminishing ?

(2) What is the relative involvement of the middle ear and of the nerve ?

Total deafness of an infected ear suggests *labyrinthitis*, and in such a case the labyrinth tests (see page 4660) must always be carried out. Total deafness can only be proved by excluding all hearing either by air or by bone in the other ear, which during the testing must be artificially deafened by some such device as the Bárány " noise box " or by continuous syringing; putting a finger in the meatus or rubbing the tragus is quite useless for the purpose.

For our purpose *partial deafness* is best measured by the spoken voice, so pitched as to be just heard plainly by a normal ear twenty feet away.

Comparison of middle ear and nerve deafness is made by the *tuning fork tests.* These are based on the comparison between hearing by air conduction and by bone conduction in the patient, and the further comparison of the results obtained with the hearing of the surgeon. For practical purposes we assume that when a tuning fork is heard by air the sound is conducted through the middle ear to the oval window and so to the cochlea; when it is heard by bone, vibrations pass in the bone direct to the cochlea (fig. 2486). Thus air conduction gives us a rough measure of the efficiency of the middle ear; bone conduction of that of the nerve.

Normally we hear better by air conduction than by bone conduction for two reasons: air-borne sounds are magnified by the conducting apparatus of the middle ear, and bone-conducted sounds are obscured by the extraneous noises heard by air. Thus hearing by bone is improved if extraneous noises are abolished by obstructing the external auditory meatus, and if there is any interference with the mechanism, either by obstruction of the meatus or by disease of

the middle ear, hearing by air is diminished and hearing by bone improved.

If there is any damage, short of destruction, of the inner ear (cochlea and nerve-endings) hearing by air and bone are both diminished; but, as the conducting apparatus, with its power of magnification, is still intact, air-conducted sounds will be heard much better than those conducted by bone.

These remarks do not apply to the higher notes. The normal hearing range is from 16 to about 20,000 double vibrations per second.

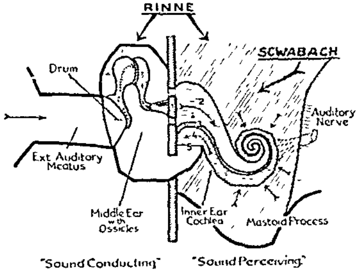


Fig. 2486.—Diagram depicting passage of sound waves.
1. Stapes.
2. Scala vestibuli
3. Lamina spiralis
4. Scala tympani.
5. Fenestra rotunda

(Modified from M. Schwarz, "Erbe Taubheit." Thieme, Leipzig, 1935.)

Above 4000 double vibrations the magnifying action of the middle ear does not affect the sounds, and the very highest notes are heard better by bone than by air.

We can say that damage to the middle ear affects air conduction more than bone conduction, and interferes more with the low notes than with the high; damage to the inner ear affects bone conduction more than air conduction and high notes more than low ones

On these observations we base the hearing tests by tuning forks:

(1) *The Weber Test.* A tuning fork of 256 double vibrations is struck, and the base is placed on the mid-line of the skull. The sound is "lateralised" to the deaf ear in diseases of the conducting apparatus; to the good ear in diseases of the cochlea.

(2) *The Rinne Test.* A tuning fork of 256 double vibrations is used. The base of the fork is applied to the base of the mastoid process, and then the fork is moved and the tips of the prongs are held as close as possible to the meatus. The fork should be heard by air for some seconds longer than it is by bone; this is the "positive" Rinne test. If it is heard longer by bone than by air, the test is "negative"

and is a sign of interference with the conducting
result is "positive" but the patient cannot h
long as a normal hearer, we speak of a
and suspect some lesion of the cochlea or
(3) *The Schwabach Test* measures bon
the fork is held to the patient's mastoid and
ver, and this alternate testing is continued until

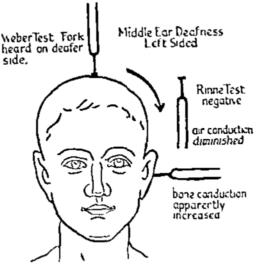


Fig [illegible] — [illegible] EAR [illegible] OBSTRUCTIVE OR [illegible] P[illegible]ESENT IN CATARRHAL [illegible] MEDIA OR IN OBSTRUCTION [illegible] THE EXTERNAL MEATUS OR EUSTACHIAN TUBE.

Rinne test Negative, fork heard better by bone than by air
Weber test Fork heard better in the deaf ear
Bone conduction Apparently increased, really either unchanged or slightly diminished.
Tone limits High tones heard better than low.

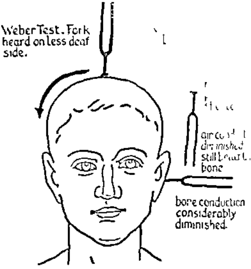


Fig 2488.—"INNER EAR," "NERVE" OR "PERCEPTION" DEAFNESS. USUALLY DUE TO INJURY, EITHER BY NOISE OR BY DIRECT VIOLENCE, OLD AGE, TOXIC CONDITIONS OR EARLY INVASION OF THE LABYRINTH.

Rinne test Positive but shortened, fork heard better by air than by bone, but by neither as well as normal
Weber test Fork heard better in the better ear
Bone conduction. Much diminished.
Tone limits. Low tones heard better than high.

longer hears the sound. Now, the test is modified by blocking the meatus of the patient and the observer with a finger so as to make both equally deaf to extraneous sounds; this is known as the test of "absolute bone conduction."

The results of the tests are summarised in the diagrams (figs. 2487 and 2488).

(4) *Estimation of the high and low tone limits* is of great importance in the accurate diagnosis of deafness, but in surgical work is rarely necessary. To do it properly we need a complete range of tuning forks, and some special instrument such as a monochord or an audiometer for the high notes.

CHAPTER II

Surgical Conditions of the Auricle and External Auditroy Meatus

THE AURICLE

The common conditions of surgical importance are hæmatoma and perichondritis. In both conditions there is an effusion, in one case of blood, in the other of pus, between the cartilage and the perichondrium; as *the skin is firmly adherent in front and loose behind, the* swelling appears on the back of the auricle; in both conditions there may be necrosis of cartilage with ultimate deformity of the auricle.

Oto-hæmatoma is usually caused by a blow, but is said to appear spontaneously in feeble patients with degenerate arteries.

Treatment. Generally the fluid is absorbed, and the only treatment needed is the application of compresses of lotio plumbi with firm bandaging. (1) If absorption proceeds slowly, light massage may be cautiously used when all tenderness has gone. (2) If there is no diminution in the swelling after a week, the fluid should be aspirated with a syringe and a wide-bore needle at the point of maximum fluctuation. This may be repeated in two days' time. (3) If these methods fail, the swelling should be incised. The incision should go through the perichondrium, but should not touch the cartilage. The clot must be mopped out as gently as possible, all bleeding points secured, the incision closed without drainage, and the ear tightly bandaged. The essential points are to avoid (*a*) starting a fresh effusion, and (*b*) infection.

Perichondritis may be due to infection of a hæmatoma, but is usually caused by infection of the wound in a mastoid operation when a meatal flap has been cut; in this case the organism is always *B pyocyaneus.* Diagnosis is established by the tenderness, redness and swelling of the auricle, with the typical bluish pus from the meatal wound.

Treatment. If the mastoid cavity is full of granulations it is packed with gauze soaked in 2 per cent silver nitrate, but if it is open all the plugging is removed and the cavity kept full of powdered boric acid.

The auricle is enfolded between two sheets of lint, thickly smeared with "Ilon salve" (an ointment of ol. sesami 30 grs., colofonium 7 grs., comp. resinoa canad.c.oxyg. act. 18 grs., acid carbol. 2 grs., and cera flava ozon. 16 grs.). Fomentations and hydrogen peroxide must not be used. If the swelling shows fluctuation it must be freely incised. Any completely loose fragments of cartilage are removed, otherwise the cartilage is rigorously respected; there must be no scraping or curetting. The incision is packed widely open with a strip of rubber dam. *After* incision fomentations may be used, for which hypertonic saline or boric acid is best.

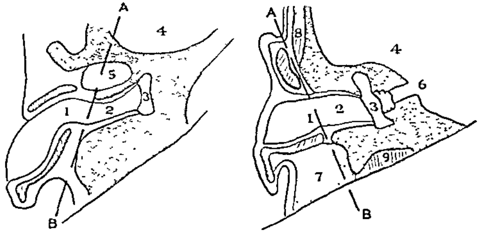


Fig 2489.—External auditory meatus seen in horizontal and vertical sections.

A—B, Junction of cartilaginous (1) and bony (2) meatus. (3) middle ear. (4) cranial cavity; (5) head of mandible, (6) internal auditory meatus. (7) parotid gland (8) temporal muscle; (9) pterygoids. Note the zigzag in the horizontal plane of the meatus, the narrow isthmus and the slant of the tympanic membrane.

THE EXTERNAL AUDITORY MEATUS

Exostoses. (1) Occasionally there is a single, pedunculated exostosis. If this is large enough to block the deep meatus and thus interfere with hearing (which it seldom does) it should be removed. The operation for impacted foreign body (see page 4612) is performed, a stout snare is slipped over the exostosis, and the stalk divided. (2) Sessile exostoses are usually multiple. Removal is always difficult and dangerous, and generally useless: *Difficult*, because they are deeply embedded in the meatal wall or arise from the tympanic ring; *dangerous*, because there is often some associated change in the structure of the surrounding bone, and capable surgeons attacking them have been rewarded with facial paralysis, labyrinthitis, fractures of the base, and meningitis; *useless*, because extreme deafness with multiple exostoses is often due to otosclerosis, and the exostoses are a manifestation of the disease, not a cause of deafness. *What must be done when there is a chronic*

middle ear suppuration in the presence of multiple exostoses which hinder drainage? No attempt must be made to remove the exostoses. The probability of infection is added to the normal risks. Some form of radical or conservative mastoid operation is undertaken (see page 4648), and if the exostoses prevent the establishment of intra-meatal drainage there must be no hesitation in establishing a permanent post-auricular fistula. It may look untidy, but the patient's safety is more important than surgical propriety.

Foreign Bodies in the Meatus. Usually there is a clear history that something has been put into the ear and has not come out; occasionally, with a child, nothing is known until the ear becomes painful and swollen. This is uncommon; a foreign body, unless it is an insect or something which can imbibe water and swell, e.g. vegetable matter, rarely causes inflammation. For this reason, in a doubtful case where the meatus is too swollen to allow inspection, skiagrams seldom help. The method of removal depends on: (1) The *patient*, nearly always a child, often a stupid child, and usually a child badly frightened by agitated parents and enthusiastic amateurs. Therefore, if there is any difficulty, do not hesitate to give an anæsthetic. (2) *The condition of the meatus.* If efforts at removal have been made, the meatus may be inflamed and swollen. If so, provided (*a*) that we know that the foreign body is not one that can swell, and (*b*) there are no signs of middle ear infection, it is better to wait until the inflammation has subsided before attempting removal. (3) The *position in the meatus* of the foreign body. Foreign bodies, except small ones such as beads, rarely get deeper than the isthmus of the meatus unless they are pushed there by injudicious treatment. (4) The *nature of the body* is important. A soft body that can swell must be removed without delay; a hard body that is not causing acute symptoms may be dealt with at leisure. *Beads* can be removed with a wool-coated probe soaked in collodion, to which the bead will stick. *Insects*, if not dead, must be killed with a few drops of 5 per cent cocaine.

Forceps are the most useless and dangerous weapons which can be chosen for the removal of a foreign body: the foreign body usually slips, so do the forceps, and the patient is lucky if he escapes with a badly scratched meatus. Lacerations of the membrane are common results of attempts at extraction by forceps, and several cases are recorded where the malleus was removed instead of the foreign body.

Syringing is only permissible when: (*a*) the foreign body is loose in the meatus and the lotion can pass it and bring it out on the return flow; or (*b*) it can be broken up by the current. Syringing is *useless*:

(*a*) if a hard body blocks the meatus, as the fluid will drive it further in; or (*b*) if a small hard body, such as a bead, lies in the "gutter" between the membrane and the meatus, as there is no backwash to bring it out. Syringing is *dangerous* if the body can imbibe water and swell.

Foreign bodies can sometimes be removed by a small tube attached to a suction apparatus.

If syringing fails or is contra-indicated:

(1) A large speculum is put in, and with a good light a small curette or a right-angled hook is passed down the meatus beyond the body, which is then drawn out. If, which is rare, this fails:

(2) Open operation is needed under general anæsthesia. Preparation, instruments and position are as for a mastoid operation (see page 4636).

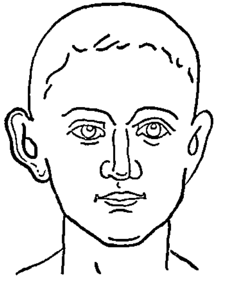


Fig 2490.—FURUNCLE.

The abscess is superficial to the periosteum, so the ear is pushed forwards but is not otherwise displaced in relation to the skull.

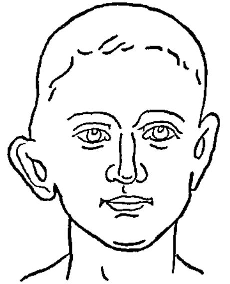


Fig 2491.—MASTOIDITIS.

The abscess starts deep to the periosteum, so the ear is pushed downwards and outwards as well as forwards.

(i) Incision for length of post-aural furrow ¼-inch behind the ear through skin and superficial fascia. Remember *that in young* children the mastoid process is poorly developed and the facial nerve superficial.

(ii) Incise deep fascia and periosteum, reflect flaps and put in Mollison's retractor.

(iii) Identify the posterior bony wall of the meatus and spine of Henle.

(iv) With a strip of gauze in forceps detach the soft meatus from the bone.

(v) The meatus is now fully open and the foreign body can be lifted out with a spoon.

(vi) The *incision is sutured without drainage*, and the meatus is lightly packed with a strip of ¼-inch ribbon gauze soaked in 10 per cent bismuth subnitrate in paraffin so as to prevent *collapse of the meatal wall.*

Furuncle of the Meatus (*otitis externa suppurativa circumscripta*) starts in a pilo-sebaceous gland of the cartilaginous meatus, and first appears as a painful and acutely tender swelling. If this is not treated it may suppurate and discharge into the meatus, or it may break through the cartilage and point behind the ear; the resultant swelling may then be mistaken for mastoiditis, especially if the lymph gland, which often lies on the mastoid process, is also infected and suppurates. The distinguishing features of mastoiditis and furuncle are shown in the following table:

	Furuncle.	*Acute Mastoiditis.*
PAIN . . .	Sudden onset and continuous pain.	Follows acute otitis media, usually after a lull, generally stabbing and intermittent.
	Increased by mastication. Increased by pulling or pressing meatus. Tenderness often most over pre auricular gland.	Unaffected by mastication or by pressure on meatus or pinna.
	Unaffected by pressure on mastoid unless mastoid lymphatic gland is affected	Increased by pressure on mastoid.
SWELLING { Internal	Usually blocks cartilaginous meatus.	Sometimes narrows bony meatus.
SWELLING { External	Pushes ear outwards and forwards Often affects pre-auricular gland. Swelling appears early.	Pushes ear downwards, outwards and forwards. Rarely affects pre-auricular gland. Swelling appears late
MEMBRANA TYMPANI	Masked by meatal swelling and debris When seen, usually normal.	Usually shows recent inflammation and perforation.
DISCHARGE	Thick and creamy from start, often blood stained at first	Usually viscid and "ropy" at start, thicker later
HEARING . .	Rarely severely affected, sometimes normal	Usually affected, sometimes, but rarely, nearly normal

Remember always:

(1) That furunculosis of the meatus may be an accompaniment of diabetes or of chronic nephritis.

(2) That furunculosis is often a complication of chronic eczematous meatitis, which may be due to chronic middle ear suppuration. Thus the patient may have mastoiditis as well as a furuncle.

(3) That if after conscientious examination you cannot make up your mind whether the patient has mastoiditis or a furuncle, he probably has both. *To operate on a furuncle as a mastoiditis is one of the most uncommon mistakes in aural surgery; it is regrettably common to waste time treating a mastoiditis as a furuncle.*

Treatment.

(1) There is swelling and induration, perhaps with a small "head" but not a true abscess.

(*a*) *Do not* incise the swelling. The result will be spread of infection with a sloughy wound, delayed healing and possibly scarring and stenosis of the meatus. *Do not* use any strong disinfectant or spirit; probably there is already some dermatitis, and chemical violence will make it worse. *Do not* attempt to syringe the ear in the acute stage; it is quite useless and abominably painful.

(*b*) *Local treatment.* The inflamed surface must be immobilised and put at rest. A piece of folded gauze is impregnated with vaseline or with antipeol and wrapped up to make a stiff wick about one inch long and the thickness of a large wooden match. The auricle is gently drawn out, the wick is inserted into the meatus with aural forceps and the end slipped past the tender area; a double layer of lint, cut to shape and thickly smeared with antiphlogistine, is laid behind the auricle, and the whole ear is covered with a double layer of lint saturated with vaseline or calamine oil. *Heat* is useful; diathermy with a large pad, an electrically-heated cushion, or a hot-water bottle may be used. *Fomentations* make the skin sodden and spread infection. They should only be used outside the greased covering, which will keep the water off the skin. In expert hands good results have been obtained by ionisation with salicylates.

(*c*) *General treatment.* Give an intramuscular injection of 2 cc. *collosol manganese.* The bowels must be well opened, but drastic purgation which will cause straining and congestion must be avoided. Chewing and biting are painful, so only soft food must be taken. For relief of pain morphia and heroin should be avoided, as they increase the congestion; aspirin and phenacetin with ½-gr. codeine phosphate is better.

(2) There is a meatal abscess without post-aural suppuration.

The abscess must be incised. *Instruments:* Headlight and battery. Aural speculum with a slot cut along the side. A blunt-ended tenotomy knife. Two pairs of aural forceps. Ribbon gauze and sterilised vaseline or antipeol. *Preparation:* Gentle cleansing of pinna and orifice of the meatus with flavine. *Anæsthetic:* Never attempt to open a meatal abscess under local anæsthesia. Gas and oxygen is adequate for the surgeon and pleasant for the patient. *Position:* Recumbent, with the head turned to the opposite side. A towel over the shoulder. *Operation:* The speculum is inserted so that the swelling presents in the slot. The swelling is then incised for its full extent in the long axis of the

meatus. Any loose slough is gently mopped out. Do not curette the cavity or damage the underlying cartilage. An abscess wall in the meatus is entitled to as much respect as any other abscess wall. Put in a wick of vaseline gauze, which must not fit tightly, and cover with a dry dressing.

(3) The furuncle has caused post-aural suppuration and a tender fluctuating swelling is present behind the ear.

Incision is necessary. *Instruments:* As for meatal abscess, with dissecting set in addition. *Preparation*: A one-inch band of scalp behind the ear is shaved. If there is much tenderness this should be done when the patient is under the anæsthetic. Pinna, skin, and orifice of meatus are cleansed with flavine. *Anæsthetic:* Gas and oxygen for choice, *never* local anæsthesia. *Position:* Recumbent, with head turned to the opposite side. A towel over the hair and a towel over the shoulder. *Operation:* Free incision through the overlying tissue to open the whole abscess. The incision must not open the temporal fascia or the periosteum in the abscess floor. The cavity is gently mopped out with gauze and the floor carefully inspected to make sure that there is no exposed bone.

(If bare bone is found there will be a strong suspicion of mastoiditis, which would be confirmed by the discovery of a fistula leading into a mastoid cell. In such a case the mistake in diagnosis should be recognised at once, and the mastoid operation performed.)

All bleeding points are secured and the cavity packed widely open with a strip of rubber dam. *If the furuncle is already discharging into the meatus it should be left alone, save for a meatal pack.* If it is not discharging but has formed a "blind" abscess, the abscess should be incised as already described.

After-Treatment of Furunculosis. Locally, treat any such predisposing cause as middle ear suppuration or chronic dermatitis. Avoid all irritants, chemical or mechanical, and eliminate such causative factors as a seborrhœic eczema of the scalp. A course of anti-staphylococcal vaccine is often useful, but administration should not begin during the acute phase.

Diffuse Otitis Externa is uncommon. It is occasionally caused by diphtheritic or Plaut-Vincent infection, but more usually by the patient's indiscreet attempts to alleviate the irritation of chronic eczema by strong antiseptics or a hairpin. The condition must always be taken seriously, as there is a considerable risk of meatal stenosis by cicatricial contraction. If an abscess forms it must be freely incised. In the diphtheritic infections, serum treatment usually succeeds; in Vincent

infections, intramuscular injections of bismuth have given the best results.

Stenosis of the Meatus may be inflammatory or congenital.

Inflammatory stenosis in the stage of activity is usually a combination of dermatitis with chronic perichondritis or even periostitis. Treatment is directed to the skin condition and elimination of any infective focus. Surgical measures against the meatus itself are unsuitable; e.g. should it be necessary to perform a radical mastoid operation on an ear with an inflamed and obstructed soft meatus, it is usually better to operate upon the bone first, drain the cavity post-aurally, and when all inflammation has subsided to perform a plastic operation on the meatus and close the post-aural wound. Post-inflammatory fibrosis may cause cicatricial stenosis. This may often be relieved by gentle, continuous dilatation with well-greased packs of ribbon gauze. Attempts at dilatation with laminaria tents must be mentioned here for unqualified condemnation. The method is intensely painful and unjustifiably dangerous. The laminaria may expand beyond the stricture, and it may then be impossible to remove it without considerable violence. If the stenosis causes serious inconvenience by the accumulation of cerumen and debris in the deep meatus, we are justified in exposing and excising the stricture by a post-aural incision, enlarging the meatus by a plastic operation, and skin-grafting the raw surfaces (see Radical Mastoid operation, page 4655). The same treatment may be needed for the *collapse of the soft meatus* which sometimes happens when it has been necessary to detach the soft meatus in a mastoid operation. *Congenital stenosis of the meatus* occasionally demands operative treatment on the same lines. We must remember, however, that in many cases the so-called "congenital stenosis" is really persistence of the infantile type of the meatus. *Complete atresia* is very rare, and is often associated with defects of the middle ear; if bone conduction is perfect and skiagrams show normal ossicles, it may be worth while attempting to form a meatus by a plastic operation. But such an operation should never be undertaken lightly; the difficulties are considerable and the benefits doubtful.

CHAPTER III

Acute Surgical Conditions of the Middle Ear and Mastoid

ACUTE SUPPURATIVE OTITIS MEDIA

Pathology. (1) *Generally*, an ascending infection of the Eustachian tube following acute naso-pharyngeal *infection, either spontaneously or* after forcing infected matter up the tube by violent blowing of an infected nose; other examples of tubal infection are the entry of infected fluid in diving; during irrigation of the maxillary antrum; during *operations under anæsthesia* with the *head in hyperextension.* Excessive zeal in scrabbling after adenoid tags, and Eustachian catheterisation in the presence of active nasal sepsis are possible causative factors. (2) *Occasionally*, infection by the external auditory meatus, e.g. following *injury of the tympanic membrane or syringing a dry perforation.* (3) *Rarely*, infection by the internal auditory meatus, e.g. in epidemic cerebro-spinal meningitis. (4) *Possibly*, from the blood stream in generalised infections, e.g. typhoid.

Symptoms and Signs. Pain is usually *intense*, with *remissions*, stabbing, and often radiating. But remember: (*a*) In some pneumococcal infections pain is almost entirely absent; (*b*) In the aged and in young children pain may be very slight; therefore examination of the drum should be a routine in all cases of unexplained pyrexia in children, whatever the signs may be, and in all cases with cerebral signs, whatever the age of the patient may be. *Redness* of the membrane is usually early and obvious. From scarlet the colour passes to dusky crimson and then to purple. Sometimes there is a *white bulging drum*; this is caused by blockage of lymphatics or by compression by the exudate, which obliterates the vessels and shows the pus through the drum. *A greyish-white lustreless drum* with obscure landmarks is probably infiltrated, and always suggests pneumococcal infection. *Swelling* first occurs in the posterior half and obliterates the line of the malleus. *Deafness* varies considerably, but there is nearly always some loss of hearing. *Vertigo* may indicate labyrinthine invasion, and must always be regarded with the gravest suspicion. *Pyrexia* is usually found, but this is an uncertain sign. In adults, the temperature is rarely above 100° F., unless there is mastoiditis with septic absorption; *in young* children, a temperature of 102° or 103° F. is not uncommon in uncom-

plicated suppurative otitis media. On the other hand, in pneumococcal infections, especially in the so-called "mucosus" infections, the temperature may never rise above 99° even in the presence of extensive mastoid disease.

Diagnosis. The conditions which may be mistaken for acute otitis media are: (1) *Myringitis.* This is usually secondary to inflammation

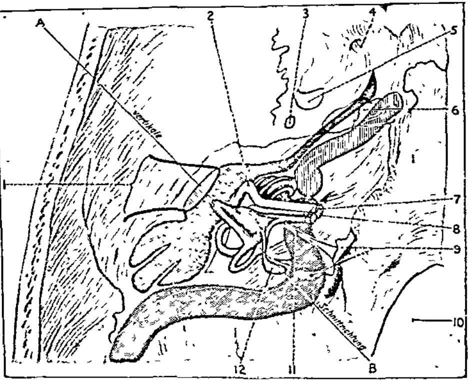


Fig. 2492.—The relations of the left outer, middle and inner ear, as seen from above. Semi-diagrammatic.

A—B, plane of the superior canal. (1) External auditory meatus, (2) facial nerve; (3) *foramen spinosum*; (4) *foramen rotundum*, (5) *foramen ovale*, (6) *foramen lacerum*, (7) cochlear nerve; (8) *vestibular nerve*; (9) jugular foramen; (10) foramen magnum, (11) aqueduct of the cochlea; (12) aqueduct of the vestibule and saccus endolymphaticus.

Lateral sinus, area shaded by slanting lines; internal carotid, area shaded by vertical lines; Eustachian tube, middle ear, antrum and cells, shown as dark grey area.

(*After Korning Denker and Kahler's Handbuch. By kind permission, Roy Soc. Med.*)

of the meatus, but may be caused by irritation of the membrane, e.g. syringing or cold air. The membrane is red, but not bulging, the landmarks (slope of the drum and position of the malleus) are unaltered, the membrane is mobile, and there is no deafness. The only treatment required is rest in bed, hot applications over the side of the head, and resolute non-intervention. (2) *Otitis externa hæmorrhagica.* This condition is rare, and occurs most often in influenza epidemics. There is sudden onset, with acute pain, and tenderness of the auricle and

meatus. There is usually a purple bulge high up, apparently of Shrapnell's membrane, but careful examination shows that this is a blood-filled blister on the meatal wall; the hearing is unaffected and the drum is mobile. The treatment is to dust the meatus with a powder of bismuth tribromphenate, cover the ear with a dry dressing, prescribe a sedative, and send the patient to bed. Most cases clear up in forty-eight hours; occasionally the membrane is attacked and acute otitis media follows. (3) *Herpes oticus* (polyneuritis acustica). This condition is very rare. Statistics show one case in four thousand ear cases. Four varieties are recognised: (*a*) With facial palsy (geniculate ganglion); (*b*) With facial palsy and deafness (geniculate and spiral ganglia); (*c*) With facial palsy and vestibular signs (geniculate and Scarpa's ganglia); and (*d*) With additional implication of the vagus and glosso-pharyngeal ganglia. In all cases the facial paralysis is probably due to pressure on the motor fibres by swelling of the geniculate ganglion and by exudate. The condition is distinguished from acute otitis media by the distribution of the blisters, which is limited to the area of distribution of the geniculate ganglion, i.e. the postero-superior portion of the

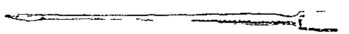


Fig 2493.—Correct shape of myringotomy knife. (*Mayer and Phelps.*)

drum and the adjacent meatal wall, the absence of pyrexia, the disturbance of taste due to interference with the chorda tympani, the presence of lymphocytosis in the cerebro-spinal fluid and the absence of leucocytosis in the blood picture. The only treatment possible during the attack is relief of pain, by morphia if necessary, protection of the blisters against infection, and support of the paralysed facial muscles. For treatment of the facial paralysis see page 4686.

Treatment. (1) There has been an attack of acute otitis media which is subsiding without perforation of the membrane. Pain has absolutely ceased, the temperature is normal, hearing is returning, and there is no headache, drowsiness or vertigo. This is a sub-acute otitis, and if all these provisos are fulfilled it is justifiable to refrain from incision. (2) The condition has subsided except for a localised collection bulging a small area of the drum; that area should be incised. (3) The drum has already been perforated, pain is relieved, and the temperature has fallen; leave well alone, but watch the mastoid. (4) The drum has perforated, but it still bulges and the discharge pulsates: the drainage is inadequate. Either the mastoid is already infected or the perforation is not large enough. If mastoiditis can be excluded, enlarge the perforation. (5) Otherwise, and when in doubt, incise the drum.

taking care not to scratch the skin. (3) Mark the lowest point of t maximum bulge, push the point through the membrane, and raisi the knife with a steady movement slit the membrane from bottom top. (4) Withdraw the knife with the edge against the postero-superi meatal wall, incising this for 5 mm. outwards from the membrane open the periosteal pouch (5) Cover the ear with a dry dressing.

Some Difficulties of Myringotomy

(1) A child with an earache screams and struggles so as to mal examination difficult. The more difficult it may be, the more essenti

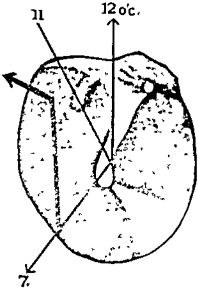


Fig. 2497.—MYRINGOTOMY. (RIGHT TYMPANIC MEMBRANE.) THE LINE OF INCISION (INDICATED BY DARK LINE WITH ARROW POINT) RUNS FROM 7 TO 11 O'CLOCK, AND IS CARRIED OUTWARDS OVER THE MEATAL WALL TO OPEN THE PERIOSTEAL POUCH.

it is that the examination should be thorough. We must not hesitate to give an anæsthetic, having warned the parents that we may have to incise the membrane.

(2) Pain with impacted cerumen is always a danger sign. It may be due to acute otitis media. Here, too, if need be, an anæsthetic should be used, and the same warning should be given.

(3) Occasionally a patient objects to an incision as he fears that "puncturing the drum" will make him deaf. We are, however, always justified in doing so since, even if incision does not save the hearing, it cannot adversely affect it; "waiting for the drum to burst" imperils his hearing and may possibly imperil his life.

(4) It is unwise to say that timely myringotomy will prevent mastoiditis. The usual opinion is that it will diminish the risk. b that is as much as can be said, and even this is doubted by some au . It is certainly true that in some cases the middle ear and

fections seem simultaneous. On the other hand, myringotomy offers a hope of drainage, and certainly relieves pain. Therefore we are amply justified *in performing this operation.*

(5) There are no indications for making a second incision in acute suppuration. If pain and pyrexia return after an incision, the mastoid should be opened.

After-Treatment. Avoid *syringing and mopping for 18 hours. Inflamed tissues* need rest. Do not meddle until all acute symptoms have disappeared. Cover the ear with a dry dressing and change as often as need be.

(1) Never use peroxide of hydrogen drops.

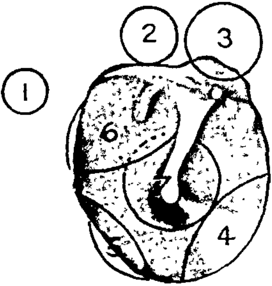


Fig. 2498.—THE COMMON SITES OF PERFORATION. (RIGHT TYMPANIC MEMBRANE.)
(1) Usual area of granulations over a mastoid fistula.
(2) Attic perforation.
(3) Perforation of Shrapnell's membrane and attic.
(4) Perforation in region of the tubal orifice.
(5) Perforation in region of sinus tympani involving margin.
(6) Postero superior perforation involving margin.
(7) "Central" perforation.

(2) Do not permit douching of the nose or gargling. Oily sprays to the nose and steam inhalations are useful and harmless.

(3) *Do not overlook a concurrent nasal sinus infection.*

(4) Do not attempt any such operation as removal of tonsils and adenoids within three weeks of the subsidence of temperature.

(5) If, in spite of adequate treatment and the absence of naso-pharyngeal infection, discharge persists for three weeks without improvement, mastoid drainage is usually indicated.

ACUTE MASTOIDITIS

By mastoiditis is meant the condition in which clinical evidence shows a suppurative process within the mastoid antrum or accessory cells, or both. The *pathology* is that of acute otitis media. Three principal forms of mastoiditis are recognised: (1) A general infection without localisation (the conjuncto-phlegmon); (2) A more or less *localised* collection of pus (empyema); and (3) Acute necrosis.

General considerations. The signs, symptoms, and course of mastoiditis *are determined* by three factors: *the anatomical structure of*

the mastoid, the nature and virulence of the infecting organism, and the resistance of the patient.

(1) *Anatomical structure.* The most common is the *cellular*; the *diploetic* is less common; the *eburnated* is rare (about 2 per cent). For convenience the diploetic and eburnated are classed together as "compact" or "acellular" mastoids. Every combination of these types is found. In the *cellular* mastoid, inflammation easily reaches the outer table, and the typical signs of mastoiditis are found. The intercellular trabeculæ are destroyed, and as there is a larger surface for absorption general signs of infection appear early. But if the cells are few and the outer table is thick, suppuration will go on in the antrum with little surface disturbance; the only signs will be those of continued middle ear suppuration, and the disease may become chronic or may attack the inner table and invade the cranial cavity. Thus it is far easier to recognise mastoiditis in a cellular mastoid; on the other hand, mastoiditis *in a compact mastoid, once recognised, is easier to cure,* as there is less chance of infection burrowing along deep chains of cells. The danger of a rapid spread of disease in the bone is greater in the cellular mastoid; in the compact mastoid where the bone is more resistant, the danger is that infection can reach the cranial cavity more easily than the surface. The most dangerous type of mastoid is that with cells buried deeply under a thick outer table, which permits a rapid deep extension with scanty surface signs.

(2) *The nature of the infection.* The two extremes, equally dangerous in different ways, are the *fulminating streptococcal infections,* usually associated with acute tonsillitis and pharyngitis and often with a generalised infection of the whole upper respiratory tract, and the *pneumococcal infections* of the "mucosus" type. The organism here is the pneumococcus III, sometimes called "*streptococcus mucosus capsulatus.*" The peculiarity of the condition is the slow, steady advance with extensive destruction of bone and almost complete absence of the classical signs. There is very little discharge, and very little pain—at the most an occasional "stab" in the middle ear. Pyrexia is trivial, or often absent, although the patient looks and feels unaccountably ill. Often there is no tenderness at all. In cases of this group our diagnosis depends on the closest observation of small details. The danger of this condition is that it may pass unrecognised until the infection invades the labyrinth or the cranial cavity.

(3) *Resistance of the patient.* Mastoiditis in *diabetics*: The patient's resistance to infection is low, and the liability to coma is increased by the infection. Far from being a contra-indication to operation,

diabetes is a reason for operating as soon as possible. Whenever possible, the following are desirable: (1) Gas and oxygen anæsthesia. (2) Blood-sugar estimation and controlled insulin administration before and after operation. (3) Removal of stitches and wide opening of the wound at the least sign of redness or œdema around the edges. "*Toxic mastoiditis*" or "*acute mastoiditis with a septicæmic state*" is of two kinds: the first is the "fulminating" mastoiditis, already mentioned; the second is characterised by the intensity of the general signs, the prostration with a rapid and weak pulse, sometimes at first little pyrexia, and scanty local signs. The problem in these cases is to choose the right time for operating.

Diagnosis. From these conclusions it follows that signs and symptoms vary widely from case to case. *Pain:* The mastoid antrum and cells are poorly supplied with nerve-endings. Pain is due to irritation of: (1) The middle ear; (2) the periosteum; and/or (3) the dura. *Headache* should always raise suspicion of dural irritation. *Continued or recurring pain after myringotomy is proof of mastoid infection. Tenderness* at the tip of the mastoid process is often found in acute otitis media without mastoid infection, and is unimportant unless it persists in the presence of free discharge. Tenderness in the supra-meatal triangle is strongly suggestive of mastoiditis. Tenderness on the posterior margin of the mastoid (Greisinger's sign) is almost positive proof of mastoiditis. *Tenderness coming on in the presence of free discharge is definite proof of mastoiditis. Swelling:* In young children the maximum swelling is often *above* the ear. *In zygomatic mastoiditis the roof* of the meatus is often pushed down. Swelling or "sagging" of the postero-superior wall of the *deep* meatus is proof of mastoiditis.

Otoscopic examination. When the bone of the mastoid process conceals suppuration in the antrum, the membrane often reveals it. As a rule, so long as there is acute inflammation within the antrum the drum shows signs of it, such as redness, swelling, and bulging of swollen mucosa through the perforation. Occasionally the drum is unaffected throughout the infection, but this is rare. A pallid opaque membrane, with obscured landmarks due to leucocytic infiltration, is characteristic of mucosus otitis (pneumococcal). Pulsating discharge is rightly regarded with suspicion, but all that it proves is that the tympanic drainage is inadequate. Cessation of discharge with persistent otoscopic signs is always a warning signal. So is discharge which is too profuse to come from the tympanum alone. If the discharge is thick and creamy, it comes from the mastoid, and is due to destruction of bone. If it is mucoid, it may come from the mastoid or from the Eustachian tube; if

it comes from the Eustachian tube, it will almost certainly come through an antero-inferior perforation. *Hearing* is usually altered to some extent, but the alteration is a measure of the intra-tympanic disturbance, and not directly of the degree of mastoid disease. Generally the deafness is of the middleear type unless there is labyrinthine invasion or profound septic absorption. A feature of the "mucosus otitis" infection is the disproportionate severity of the deafness as compared with the local signs.

Pyrexia. Of all the symptoms this is the least reliable. In adults the temperature rarely reaches 101° F. unless a blood infection is present. *Rigors* suggest invasion of the lateral sinus. Persistent pyrexia may be due to infection of the skin or lymphatic glands, or to the naso-pharyngeal condition which caused the acute otitis media. On the other hand, there may be no pyrexia with a rapidly advancing infection. The comparison of the pulse: temperature ratio sometimes helps greatly. A pulse-rate too slow for the temperature hints at intracranial extension. A sudden increase in pulse-rate without an equivalent rise of temperature often warns us of a wave of toxæmia overcoming the body resistance.

Some Examples of Mastoiditis

(1) *The typical case.* A child has a cold. During this there is an acute otitis media with pain and pyrexia. The drum bursts or is incised, pus escapes, pain is relieved. and the temperature falls. For ten days the ear discharges: then the discharge diminishes, pain returns, and the temperature rises There is a red drum with pulsating fluid in the perforation, bulging of the posterior superior wall of the deep meatus, and tenderness over the mastoid process, especially in the region of the supra-meatal triangle. The *general condition* is not seriously affected; there may be moderate fever, rarely above 100° to 101° F. in adults, a proportionate increase in pulse-rate, and a polymorphonuclear leucocytosis. *Hearing* is usually altered.

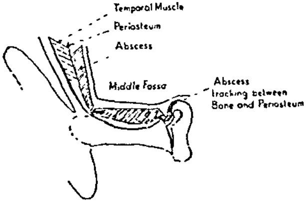
(2) *The advanced case with signs of subcutaneous extension.* This is the "classical" case, which is not often seen now except in young children. Suppuration has penetrated the outer table, and there is *periostitis* with or without a subperiosteal abscess. This condition may be (but should not be) confused with *furuncle* (see page 4613) or with suppuration of a mastoid lymph gland. If there is any real doubt about it, it is probably a mastoiditis. There is one rare condition which is exceedingly difficult to distinguish from mastoiditis. This is a *subperiosteal extension of an acute otitis media* (Luc's abscess) (fig. 2499). Such an abscess, if recognised, could probably be treated by free incision of the

meatal roof. In practice, the conscientious surgeon who regards it and operates on it as a mastoiditis need not reproach himself; he has provided the best drainage and has only erred on the side of safety, for there is no certain method of distinguishing this very rare condition from the not uncommon "*zygomatic mastoiditis.*"

(3) *The grumbling mastoid.* This is usually a mastoid empyema contained in a dense cortex. Suspicion is aroused (*a*) by continued thick discharge, perhaps pulsating, occasionally diminishing, with niggling jabs of pain, or (*b*) by a *sensation* of pulsation, synchronous with the heart beat, usually painless but associated with a persistently red drum (Scheibe's syndrome).

(4) *Mucosus otitis and mastoiditis.* This has already been mentioned, but it is of such vital importance that it is well to review our facts. A patient who has had an acute otitis media, apparently of slight

Fig. 4299.—Luc's abscess. (*Modified from Lermoyez. From "Principles and Practice of Otology," Watkyn Thomas and Yates.*)



severity, does not get well and does not feel well. He has occasional stabs of pain, and he is unaccountably deaf. Examination shows a grey, lustreless drum with obscured landmarks. If it has been incised there has been little discharge, and the edges either bulge or quickly unite. There is little or no tenderness or pyrexia and the disease often progresses unrecognised until some intra-cranial complication occurs. It is often stated that the disease has a predilection for the cellular type of bone, but this is not proved. It is certainly easier for it to spread in cellular bone, as the infection seems to advance along the sub-epithelial layer of the endosteum, destroying the subjacent cell wall in its advance. At operation the cells are seen to be full of greyish, jelly-like substance, which is sometimes inaccurately described as "*granulation tissue.*" Pus is often found in the cavities made by the breakdown of the bone, but is usually scanty. The peculiar nature of the spread makes it of the utmost importance to open up every cell of the mastoid in these cases. In mucosus otitis the blood picture often shows a falling white count

with a "left shift," and very often associated anæmia. Valuable evidence is sometimes obtained by skiagrams.

Special Forms of Mastoiditis

(1) *In infants and young children* the accessory cells are absent or scanty, the antrum is high up and forward, and the petro-squamous suture is often open. Thus there is early subperiosteal spread with much superficial swelling. It has sometimes been said that there is a

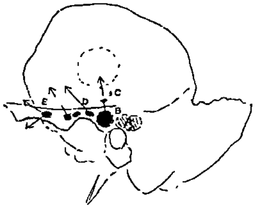


Fig 2500.—ZYGOMATIC MASTOIDITIS.
(Diagram of cells invaded.)
(A) Antrum, (B) large zygomatic cell. From this pus may track to (C), cells in the squama, and form an *extra dural abscess*, or (D), along the zygoma and *under the temporal muscle*, or (E) further still, and form a *subperiosteal abscess* on the zygoma.

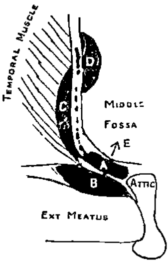


Fig 2501.—ZYGOMATIC MASTOIDITIS.
(Diagrammatic coronal view.)
Suppuration in a zygomatic cell (A) causes swelling in the roof of the meatus (B). It may reach the surface as an abscess under the temporal muscle (C), or may extend in the squama and cause an extra dural abscess at (D), or perforation on floor of the middle fossa (E).

causal association between *otitis media and summer diarrhœa in infants.* The weight of evidence is against this view. The latest researches suggest that otitis media is not more common among infants with summer diarrhœa than among other infants.

(2) *Zygomatic mastoiditis.* Infection tracks through a zygomatic cell, causing a swelling in the temporal fossa, and spreads over the head and face up to the attachment of the temporal muscle, with œdema of the eyelid, tenderness above the auricle and over the root of the zygoma,

and difficulty in opening the mouth and in biting. It may appear some days after an apparently satisfactory mastoid operation. It is often associated with extra-dural abscess, and may be followed by stenosis of the meatus. It must be distinguished from *erysipelas,* where the swelling is cutaneous, with the typical red raised edge, acute onset, high fever, and severe general prostration, and from *cellulitis of the scalp,* where the swelling is subcutaneous or subaponeurotic, spreads rapidly, is not sharply limited, pits on pressure, and does not interfere with the movements of the jaw. *Pterygo-maxillary abscess* is a rare condition which may be mistaken for zygomatic mastoiditis. The distinguishing features between the two conditions are shown in the accompanying table:

	Preceding otitic infection.	Signs of existing mastoid disease.	Trismus.	Swelling over zygoma.	Tenderness.	Dental history.
gomatic lastoiditis.	Always present.	Always present.	Never present.	Maximum swelling situated over or above the zygomatic arch.	Always present over the root *of the zygoma.*	Never present.
erygo- axillary bscess.	May be present, but not necessarily so.	Usually not present.	Usually present to a marked degree.	Maximum swelling found to be below the arch of the zygoma.	Never present over the root of the zygoma, but only over swelling.	Very often present and of great significance.

(3) *Spread into the meatus.* This sometimes happens in cases with a high deep antrum. The pus tracks through a cell in the posterior meatal wall and a swelling appears on the posterior wall of the bony meatus and usually spreads downwards. It can be distinguished from a furuncle by the fact that the swelling is in the bony and not in the cartilaginous meatus, and at first, at any rate, there is no pain on moving the jaw or the auricle. In most reported cases the drum is unperforated, or has already healed.

(4) *Spread into the neck.* (*a*) Bezold's mastoiditis. This is caused by pus breaking through a cell at the tip of the mastoid into the sterno-mastoid sheath. There is a continuous swelling over the tip into the neck, usually associated with torticollis and pain on bending the head to the opposite side or on putting the muscle into action. It is rare to find Bezold's abscess without other mastoid signs, and the fact that the swelling is limited above by the attachment of the muscle, confined to the muscle itself, and accompanied by induration of the overlying skin, distinguishes it from inflamed glands.

(*b*) Abscess in the digastric fossa. This may lie externally to the

digastric, between it and the sterno-mastoid, or may spread forward along the digastric bundle and point in the submaxillary triangle (Citelli's abscess) Both forms are rare.

(5) *Spread towards the pharynx.* This condition is rare but dangerous, as it may cause mediastinitis. It usually appears after operation. At first the only symptoms are pain, dysphagia and continued pyrexia. Examination of the throat shows a unilateral swelling, pushing the tonsil forwards and outwards Probably the usual route of infection is

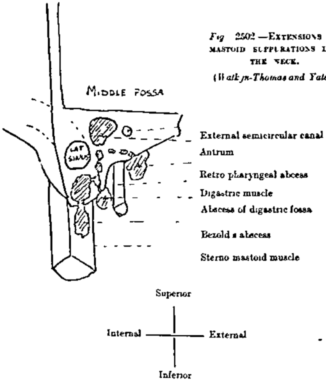


Fig 2502.—EXTENSIONS OF MASTOID SUPPURATIONS INTO THE NECK.
(*Watkyn-Thomas and Yates*)

through caries of the bone in the roof of the pharyngo-maxillary fossa, or by the downward spread of a petrosal infection.

(6) *Petrosal invasion and petrositis.* In present-day practice this is nearly always a post-operative condition, and it will be convenient to discuss it as such (see page 4645).

(7) *Intra-cranial extensions.* Here it suffices to remember that a pulse-rate too slow for the temperature, drowsiness, persistent headache, a squint, vertigo or nystagmus are danger signals which suggest intra-cranial invasion or labyrinthitis. *External rectus palsy* with mastoidtiis (Gradenigo's sign) is discussed with petrositis. *Facial palsy* occurring in the course of acute middle ear suppuration may be due to a defect in the bony wall of the facial canal or to infection of cells surrounding it.

THE VALUE OF SKIAGRAMS IN MASTOID DISEASE

An expert radiologist, with a first-class plant at his disposal, can sometimes give us great help in mastoid cases, but skiagrams which are not of the highest quality are of no use. As well as the technical difficulties of position and penetration there are difficulties inherent in the structure of the mastoid and in the pathological condition. The most experienced radiologist cannot always distinguish between solid bone and a cell filled with exudate, and it may be impossible to detect isolated cells surrounded by dense bone. It is probable that in most cases of acute otitis media there is some exudation in the mastoid cells which gives a cloudiness or " masking " not indicative of clinical mastoiditis. Positive evidence, such as destruction of bone, is of great value, especially in cases where the clinical signs are doubtful—for example, mucosus infections where the destruction proceeds quietly. But usually in early cases the clinical evidence precedes definite radiological evidence, and negative skiagrams must never be *allowed to override clinical signs*. In petrosal infections, skiagrams may be of great help if apical cells can be shown. Sometimes skiagrams will show perforations of the tegmen tympani and extra-dural collections of pus. In chronic suppuration, *skiagrams may demonstrate the presence of cholesteatoma*. On the whole, the greatest value of skiagrams is to show the arrangement and extent of the accessory mastoid cells. In their present state of development, skiagrams are an interesting and possibly helpful adjunct to diagnosis.

INDICATION FOR OPERATION

The indication for mastoid operation is the diagnosis of an acute mastoiditis. This is the *only* indication, as operation is the only treatment. It is sometimes said that mastoiditis is not a fatal disease; the fatalities are due to the complications. The same is true of hanging, where the patient dies of the resulting strangulation or from the fracture of his cervical vertebræ. For practical purposes it is reasonable to regard the mastoiditis or the hanging as the cause of death.

Apart from the danger to life, operation offers the best chance of preserving the hearing.

The Best Time for Operation—Early or Late?

It may be said that there is no " right time " for operating on all acute mastoids; there is a right time for operating on every acute mastoid. Each case must be judged on its merits, and all the circumstances must be taken into account. Some general principles can be

laid down: The *advantages* of delay are that we are not operating at the peak of an inflammation. General immunity has time to develop, so that there is less immediate reaction. The operation will be easier, and healing will probably be quicker. The *disadvantages* are that the spread of the disease is always ahead of the clinical signs, and the infection instead of localising in the mastoid may invade the meninges. The statistics are confusing, but, on the whole, it seems that erysipelas, cellulitis of the scalp, severe toxæmia and septicæmia are more common after early operation; intra-cranial complications are more common when operation is delayed. The general tendency in this country is to operate early, once the diagnosis of mastoiditis has been made, but for choice not until the fourth day after the onset of acute otitis.

(1) If the condition is obviously localising, as shown by falling temperature, well defined and increasing tenderness and absence of any signs of intra-cranial extension, and if the patient's general condition is good, it is justifiable to wait and to operate in the sub-acute state.

(2) In fulminating mastoiditis, where there is an acute tonsillitis and signs of profound toxæmia, it is advisable, if possible, to delay operation until the first violence of the attack has passed. It is so difficult to judge how much of the toxic symptoms are due to the primary condition, e.g. a streptococcal tonsillitis, and how much to the mastoid invasion that clinically, if not pathologically, these cases should often be regarded as septicæmia in which a mastoiditis serves as a fixation abscess. But this can only be done if the patient shows signs of improvement and if there are no signs whatever of intra-cranial extension.

(3) In toxic cases with leucopenia there must be no delay.

(4) In cases of mucosus otitis there must be no delay.

(5) If there is the slightest evidence of intra-cranial extension there must be no delay, but:

(6) *Waiting for intra-cranial signs before operating is like locking the garage door when the stolen car is in the next county.*

THE OPERATION FOR ACUTE MASTOIDITIS
("*Schwartze's operation*" or "*Mastoidectomy*")

The object of this operation is to cure a suppuration which endangers life, and at the same time to preserve the hearing. Therefore we must open up the whole of the infected area, remove infected bone, provide drainage, and prevent reinfection. To do this we must open up all the cells of the mastoid system; if we do not do this we may leave undrained pockets of pus or infect previously intact cells and leave them

without drainage. On the other hand, only under the most exceptional circumstances are we justified in sacrificing the structures of the middle ear in an acute suppuration. The only indications for performing a radical mastoid operation in acute conditions are: (1) Spreading necrosis of the meatal wall and roof, sometimes seen in scarlet fever and diphtheria; and (2) When a deep infection can only be reached through the tympanum, as in suppurative labyrinthitis and some intra-cranial conditions. If possible, we must avoid detaching the cartilaginous meatus or interfering with the bony meatal wall. Such tactics often lead to meatal stenosis unless a plastic operation is done, and plastic operations in acute suppurations are unsatisfactory. If the

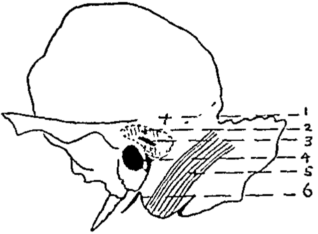


Fig 2503.—Anatomical points in the mastoid operation.
(1) Lower limit of middle fossa; (2) mastoid antrum; (3) external semicircular canal, (4) descending portion of facial nerve; (5) lateral sinus, (6) facial nerve at stylo-mastoid foramen.
(*Watlyn Thomas and Yates*)

meatal wall is necrotic or if deep cells or the antrum can be reached in no other way, it must be attacked, but only under those conditions.

Anatomical points.

(1) *Situation of the antrum.* The orthodox surface marking is "Macewen's triangle," which is formed by the posterior superior arc of the bony meatus and the tangents drawn through the highest and most posterior points of the bony wall; this nearly corresponds to the "supra-meatal triangle" which lies between the posterior and horizontal roots of the zygoma. This marking is often too low, the floor of the antrum in many cases being on a level with, or even above, the horizontal line drawn through the summit of the bony meatus. In infants the antrum is directly above the bony meatus. The spine of Henle, which is said to mark the level of the aditus, is too inconstant in size and position to be of any use. A line drawn from the antrum across the tympanum and down the Eustachian tube (the antral-tympano-tubal axis) passes downwards, forwards and inwards at an angle of 45 degrees with the median sagittal plane of the skull and of 30 degrees with the horizontal (see fig. 2504). It follows that the outer wall

of the antrum must always be superficial to the plane of the tympanic membrane. The antrum is always present, although in exceptionally rare instances it may only be a " chink " behind the aditus. (The writer has seen only one such case in twenty years.)

The depth from the surface varies considerably. It is probably never more than two centimetres. The mastoid cells begin to appear at the end of the first year of life.

(2) All surface guides to *the middle fossa and lateral sinus* are unreliable. When present, the petro-squamous suture is a rough guide to the descending part of the lateral sinus. The horizontal limb of the

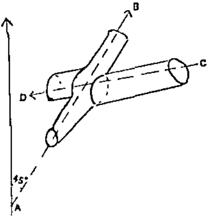


Fig. 2504.—A—B, antral-tympano tubal axis; C—D, axis of the internal and external auditory meatuses.

zygoma is often given as a guide to the floor of the middle fossa, but it cannot be trusted.

Quite roughly, a small " knobby " mastoid with few cells usually goes with a low middle fossa, a forward lateral sinus, and a high deep antrum.

(3) *The position of the facial nerve* is constant. The downward bend lies about 3 millimetres below the floor of the aditus, and the nerve in the adult is never superficial to a plane drawn from the prominence of the external semicircular canal through the highest point of the floor of the bony meatus parallel antero-posteriorly with the antral-tubal axis. The danger to the nerve in operations behind the meatal wall is in following up cells which undermine the wall and may impinge on the facial canal. In young children, where the mastoid process is undeveloped, the nerve is subcutaneous where it crosses the styloid process, and may be divided if the skin incision passes below the bone. This must never be forgotten, as such an accident has been known to occur.

(4) *The external semicircular canal* lies in the floor of the aditus, and can be recognised as a smooth white bulge.

(5) *The accessory cells.* Nine groups of cells are described. The general arrangement is shown in figure 2506.

Fig. 2505.—Course of the facial nerve in the middle ear.

(1) External semicircular canal, (2) course of facial nerve marked by a wire; (3) fenestra ovalis, (4) sinus tympani.

(*From A. A. Gray, "Atlas of Otology"*)

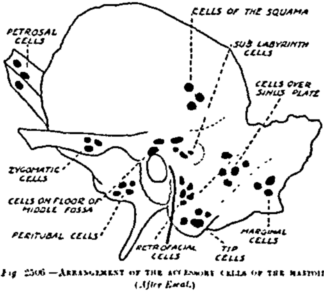


Fig. 2506.—Arrangement of the accessory cells of the mastoid.
(*After Eneal.*)

This diagram follows von Neumann's description, with the addition of "cells of the squama. Kirschner's cells are included in the "cells on the floor of the middle fossa. Broca's cells with the "retrofacial." The intersinuso facial group is derived from the retrofacial, the cells of the tip, and those over the sinus plate

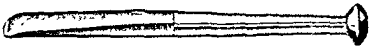


Fig. 2507.—A flat backed, well-rounded gouge.

Instruments. Dissecting set, periosteal elevator, automatic mastoid retractor (Mollison's pattern, fig. 2508), a pair of small retractors, mallet, three gouges of different widths, bone forceps, small sharp curette, two pairs of aural forceps, aural specula, myringotomy knife, curved needles, catgut, silkworm-gut, rubber drainage-tube and rubber dam, 100 gauze strips (6 × 1 inch), gauze squares, wool, gauze and bandage for dressing, sterile vaseline, head-lamp and battery.

A note on the choice of instruments. A wooden mallet is less tiring to use than a metal one, and usually balances better. Gouges should be well-rounded, flat-backed and sharp enough to trim the thumb-nail. "The wider the gouge the safer the dura" is a good rule. Chisels should never be used near the dura; their only use is in the radical mastoid operation for taking down the posterior meatal wall. Curettes are a necessary evil. They should be strong and sharp. We cannot

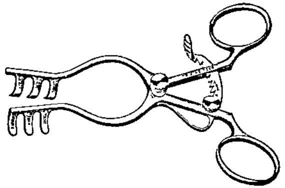


Fig 2508 —MOLLISON'S AUTOMATIC MASTOID RETRACTOR.

absolutely avoid using them, but remember that most of the accidents in mastoid surgery are caused by curettes. Bone forceps should have well-rounded ends; the sharp-ended abominations often sold as "forceps for mastoid operations" are admirably suited for tearing the dura, and for nothing else.

Anæsthesia. The choice should be left to the anæsthetist. Chloroform should be avoided in patients suffering from severe toxæmia; local anæsthesia should be avoided in all patients. The anæsthetist must keep a free airway. There has recently arisen a comfortable and unfounded belief that mastoid cases present no particular difficulties from the anæsthetic point of view; it is a belief to be discouraged.

Preparation of the Patient. If the patient can wait overnight, an aperient should be taken in the evening and an enema given in the morning. Otherwise an enema before operation is all that is required. Drastic purgation should be avoided.

Preparation of the Skin. For all the mastoid operations a band of

scalp, 3 inches wide, should be closely shaved. If time allows, as in the chronic conditions, the whole head should be well washed before the operation. *If the skin is tender, shaving should be deferred until the patient is anæsthetised.* The shaved skin should be well scrubbed with spirit and painted with picric acid, and the hair pulled back and kept out of the way with two bands of strapping or by gauze with collodion or mastisol. Particular care should be taken in cleaning the folds of the pinna. If the ear is discharging, the meatus should be syringed out with 1 in 40 carbolic in water. This penetrates the fatty secretion of the sebaceous glands more efficiently than spirit.

Arrangement of Towels. The best way to apply the head towels is to take two—one open and one folded lengthwise. These are held together, outstretched, with the folded towel towards the surgeon. The nurse raises the patient's head, holding the hair away from the prepared skin, and the towels are put under the head with the folded towel on top. The folded towel is then wrapped tightly around the head, leaving the pinna free, and is fastened with clips. A long towel is drawn up over the patient's chest and clipped to the folded towel. Another towel is then laid on and fastened in front of the pinna, but this should be arranged so as not to impede the anæsthetist's view.

Position. Recumbent, with the head turned to the opposite side *and a small flat sand-bag under the cheek. If the head is turned too far* the anæsthetist will have difficulty in maintaining an adequate airway, thus producing congestion with excessive bleeding and general discomfort to everyone concerned. There must be no " hump " of blanket on the patient's chest, as this may cramp the movement of the elbow. The patient must be placed in exactly the right position before starting the operation. The anæsthetist is seated at the patient's sound side, the operator stands or sits facing him, and the assistant stands between the two at the head of the table.

Stage I. With the pinna held forward the incision is made from the level of its upper attachment to the tip of the mastoid process, which is marked with a finger. The incision should lie ½-inch behind *the attachment of the pinna. Too generous extension forward over the* upper attachment may cause the whole pinna to drop. In infants and young children the incision must not be carried below the bone, as the mastoid process is not yet formed and the facial nerve is subcutaneous. The incision traverses only skin and superficial fascia unless *swelling is present. Next, the incision should go down to the periosteum* in the lower half of its length and through it if pus is present. The vessels are secured, and the skin is retracted to expose the temporal

fascia and the bone. If possible, the temporal fascia should not be opened; injury to the temporal muscle means troublesome bleeding and possible infection of the sheath. The periosteum is divided by a vertical cut down the middle of the operative field. The fibres of the sterno-mastoid attached to the process are divided transversely close to the bone, and with the periosteal elevator the surface of the bone is scraped clean from tip to temporal attachment, care being taken not to let the elevator slip round the mastoid into the neck. The periosteum is detached forwards until the bony margin of the meatus can be clearly defined, and backwards as far as the edge of the process. The bone is examined for a fistula or necrosis. The automatic retractor is inserted and opened widely, care being taken not to detach the cartilaginous meatus.

Stage II. The operator now finds the landmarks:

(1) The posterior superior arc of the external auditory meatus with the spine of Henle in front;
(2) The posterior horizontal root of the zygoma above; and
(3) The tip of the mastoid below.

If no fistula or carious bone is found, removal of the outer table is begun with a 16 mm. gouge laid nearly flat on the bone, so that a thin shaving is taken off. Three cuts are made centring on the little depression just behind Henle's spine:

(*a*) Straight forward just below the zygomatic ridge from the posterior edge of the bare area to $\frac{1}{4}$-inch from the meatal margin;
(*b*) Obliquely from the posterior edge upwards to join the first;
(*c*) Vertically from the tip upwards to join the other two (figs. 2509 and 2510).

This exposure will show the degree of cellularity of the bone, and the type of infection—whether empyema, phlegmon or acute necrosis—and may give a hint of the position of the middle fossa and sinus. In some acute infections there is free bleeding from congested bone and from swollen granulations. No cut should be made into a pool of blood. A strip of gauze should be packed tightly into the cavity and left for some twenty seconds. The assistant removes it in one piece with forceps, and the operator has a few seconds' respite in which to make another cut. Bleeding from swollen granulations is best checked by rubbing them away with gauze held in forceps. This must be done gently, as the granulations may lie on bare dura. It is not uncommon to mistake a patch of flabby granulation peeping out of a large cell for the dura of the sinus wall. If the bleeding comes from a small vessel in the bone, it is

best controlled by snipping off a piece of sterno-mastoid muscle the size of a match-head, and holding it firmly on the bleeding spot for two minutes. This will adhere and stop the bleeding as long as it is in position.

If pus is found at this stage, it should be mopped away and its source noted. It is unwise to pursue it with a probe, since it is only too easy to damage a sinus wall covered with granulations. The same warning applies to pushing in gauze blindly with sharp-pointed forceps.

The rough right-angled triangle we have made by our three cuts is *widened and deepened by further cuts, principally from the hypo*thenuse, with the same precautions as before to control bleeding. This is continued until no more cells or infected bone are found along the

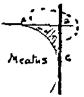


Fig 2509.—Macewen's triangle, ABC. The usual position of the antrum is shown by the broken line It is often still further forward.

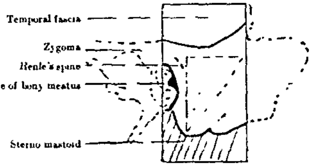


Fig 2510.—Preliminary exposure.
Area within the dotted triangle marks the first gouge cuts.
(*Watkyn-Thomas and Yates.*)

posterior edge. Probably the "sinus plate," the dense bone overlying the lateral sinus, can now be recognised. With smaller gouges the forward and upward portion of the triangle in front of the sinus plate is attacked by light cuts forwards and by straight cuts inwards, at first parallel with the meatal wall, and then parallel with the floor of the middle fossa, in order to free the chips of bone. These vertical cuts must be *lightly made with a gouge held firmly to avoid a sudden plunge into and* across the antrum, which might injure the external canal. By these cuts a cell is reached. Is that cell the antrum? One of the commonest mistakes a beginner makes is to open a cell overlying the antrum and not the antrum itself (see figs. 2511–2513).

If a sinus or patch of carious bone is present, this is opened first, and the track is followed up to the antrum. The surrounding bone is then attacked as *before*.

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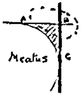
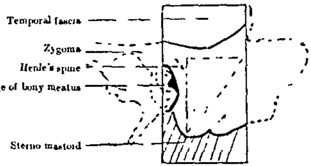


Fig 2509.—Macewen's triangle, ABC. The usual position of the antrum is shown by the broken line. It is often still further forward



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If a sinus or patch of carious bone is present, this is opened first, and the track is followed up to the antrum. The surrounding bone is then attacked as before.

Stage III. The only way of recognising the antrum with certainty is by identifying the aditus, and the only way of identifying the aditus with safety is by seeing it. "Proving the aditus" by putting in a bent probe or a Stacke guide is dangerous, as it is so easy to dislocate the

SOME COMMON MISTAKES.

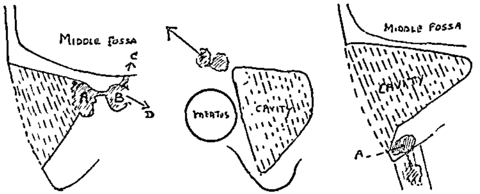


Fig. 2511.—The operator mistakes the large cell (A) for the antrum (B). He does not drain the antrum properly, and suppuration continues. Perhaps an intra-cranial abscess (C) or a chronic middle ear suppuration (D) may follow.

Fig. 2512.—The operator does not open the chain of cells in the root of the zygoma above the meatus. Suppuration tracks forwards along the squama and the zygoma.

Fig. 2513.—The operator misses a "secondary" cell (A) at the tip. Suppuration extends into the sterno mastoid sheath.

(*Wall, in Thomas and Yates.*)

incus. The opening is carefully enlarged with a small gouge until all overhanging bone has been cut away. When working forwards behind the meatal wall the facial nerve is in some danger, so that the anæsthetist should watch the patient's face for any muscular twitch. The cavity is

Antrum opened

Sinus plate exposed

Cell at apex opened

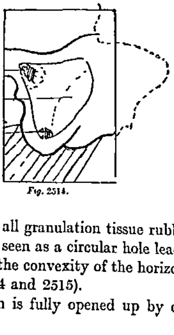


Fig. 2514.

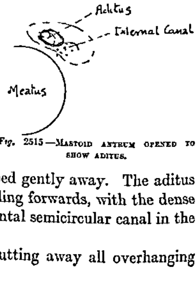


Fig. 2515.—MASTOID ANTRUM OPENED TO SHOW ADITUS.

dried out, and all granulation tissue rubbed gently away. The aditus should now be seen as a circular hole leading forwards, with the dense white mass of the convexity of the horizontal semicircular canal in the floor (figs. 2514 and 2515).

The antrum is fully opened up by cutting away all overhanging

walls, and search is made for remaining cells. It is of the utmost importance that this should be done thoroughly. In pursuing the cells it is well to follow some definite scheme, such as the following:

(1) *Cells in the neighbourhood of the antrum.*

(*a*) Cells in the antral roof under the floor of the middle fossa are sought first. They are usually found in removing any upper overhang.

(*b*) Cells lying in the root of the zygoma and outer attic wall. A gouge cut at the angle of the bony cavity and just above the meatus will open these. If necessary, the temporal muscle must be retracted, and the pinna pulled forward in order to follow them.

(*c*) Behind the antrum in the angle between the lateral sinus and the floor of the middle fossa.

(2) *Cells behind the lateral sinus.*

These have been opened by our preliminary gouge cuts. If tenderness on the posterior edge has been noticed before operation, the cell that gave rise to this tenderness must be found. These cells must be followed back to their limit. If necessary, the incision must be enlarged by a horizontal cut backwards through the scalp.

(3) *Apical cells.*

The apex is clearly defined and fully opened. If only a shell is left, or if there is any extension of suppuration into the neck, it is better to remove it completely. To do this a flat retractor should be placed under the tip to guard against a slip, and the tip freed by one gouge cut in front and another behind. Three structures must be avoided: the facial nerve in front, the mastoid emissary vein behind, and the occipital artery internally.

There are two regions in which cells may have been overlooked (fig. 2516):

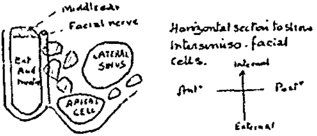


Fig 2516.

(*a*) In the groove between the posterior meatal wall and the lateral sinus there is frequently a chain of cells leading from the antrum to the apex. These cells sometimes lead into the sinus groove. The anæsthetist should watch the face as the cells may overlie or undermine the facial nerve.

(*b*) In rare instances, a " cuff " of cells surrounds the labyrinth and extends into the petrous. If such cells are present they are usually found on the deep antral wall, and must be carefully followed.

Closure and Drainage. The cavity is mopped out. In the majority of cases, it can be safely closed with a few interrupted silkworm-gut sutures, and drained by two small tubes laid along the length of the wound from above downwards. In septicæmic or toxic cases, or where granulations are found on an exposed dura, it is better to leave the wound widely open and to pack loosely with a piece of india-rubber

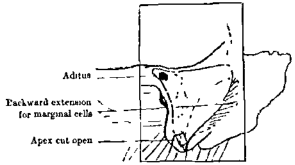


FIG. 2517.—ANTRUM FULLY EXPOSED AND TIP CELL REMOVED. TEGMEN EXPOSED ABOVE. The dotted area between apex and antrum marks the intersinuso facial cells.

dam. Recently, some surgeons have advised complete closure after allowing the wound to fill with blood clot. This does not seem to have any advantages over tube drainage, and certainly has added risks.

SOME DIFFICULTIES

(1) *Failure to find the Antrum.*

The commonest mistake in seeking the antrum is to look too low down and too far back. A careful removal of bone forwards and upwards, hugging the temporal floor and the meatal wall, will lead us to it. Sometimes the low middle fossa and the forward lateral sinus, especially in dense bone, leave no room for the ordinary method of approach. Here we must ruthlessly sacrifice the posterior meatal wall. The cartilaginous meatus is detached and pushed forward. The postero-superior arc of the meatus is attacked ; a series of gouge cuts centred on an imaginary point in the middle of the meatus, driven downwards, forwards and inwards, carrying Henle's spine and the surrounding bone, will expose the antrum. Some of the outer attic wall and meatal roof may be removed at the same time. This method looks dangerous, but is really quite safe. It should be completed by making a small plastic flap. The result is practically a Heath operation.

Another method of reaching the antrum under these circumstances

is to expose the posterior superior meatal wall and cut backwards and inwards from the meatus just above the attachment of the membrane. (This is the original Stacke operation.) The method has a limited applicability.

(2) *Damage to the Lateral Sinus.*

There are few operators who at some time or other have not injured the lateral sinus; there are few patients who have been any the worse for it. It is, however, an error to guard against, for the danger of a thrombosis, although slight, is quite real, and the hæmorrhage may be so profuse as to disconcert even an experienced operator. The accident is best avoided by the use of broad flat gouges, and by watching for any exposure. If it is necessary to work on the sinus groove with an exposed sinus, it is wise to pack the dura away from the bony wall with gauze. Particular care must be taken in the use of bone forceps around the sinus. The most likely cause of injury is damage to an emissary vein or to a dura already softened by granulations. If a hæmorrhage occurs it can always be controlled; there is no recorded case of a patient dying on the operating table from a hæmorrhage from the lateral sinus. Small scratches can be controlled by packing over or patching them with a graft of muscle or fascia snipped off the temporal or sterno-mastoid and held in position for about two minutes. This will control an extensive hæmorrhage, but in the case of a large tear it is better to face the possibility of having infected the sinus, and to obliterate it completely by a full exposure and by packing the walls together from outside. *Under no circumstances should packing be placed in the sinus.*

(3) *Injury to the Dura*

This also can usually be avoided by the use of broad gouges. It seldom gives trouble if the accident is recognised. The injured area should be freely exposed and painted with iodine, and the wound lightly packed, but not stitched and tubed.

(4) *Injury to the Facial Nerve.*

This rarely happens in operations for acute mastoiditis. Precautions against it have already been described.

(5) *Injury to the External Semicircular Canal.*

This may be caused by a plunge of the gouge across the antrum. It will be recognised on the patient's recovery by the signs of labyrinth irritation. Such a case should be carefully watched for spreading labyrinthitis. This is an uncommon accident.

After-Treatment. Whether the wound is tubed or packed, strips of gauze are laid over it, fitted to the retro-auricular groove, and wool is then tucked between

gauze and pinna. Another sheet of wool is laid over the pinna, and the whole secured by a mastoid bandage. The patient is put to bed lying on the sound side, the head slightly raised to relieve tension. A rectal saline with glucose, sodium bicarbonate and potassium bromide should be given; post-operative pain is rarely severe. The outer dressing is changed on the morning after the operation; tubes are gently syringed out on the second, and loosened on the fourth morning. Packing should be changed on the third morning. There should be no hesitation about giving a timid patient gas for this. Packing is usually continued for three weeks at least. After the first ten days lotio rubra or one of the "scarlet red" preparations may be substituted for flavine. In the ordinary run of tubed cases, the tubes are changed on the fifth day and removed on the tenth; between the fifth and tenth days they can be shortened daily.

GENERAL TREATMENT

Bowels should be kept open, but violent purgation must be avoided. In the *toxic cases* the patient must take as much fluid as possible, e.g. weak tea, lemonade, Imperial drink, etc.

Vaccine treatment has dangers even in the most skilled hands. In streptococcal cases the anti-scarlatinal serum has given satisfactory results. Intravenous disinfectants (colloidal preparations, etc.) have been disappointing on the whole, although some remarkable successes have been obtained. In some streptococcal infections intravenous injections of 0·1 per cent perchloride of mercury in normal saline have been valuable. Hypertonic saline (10 per cent) given intravenously in 10 to 20 cc. doses has proved the most beneficial. Whole blood-transfusions have also given good results in severe cases where there is definite anæmia. Prontosil may also be given a trial.

COMPLICATIONS

The temperature should fall to normal in 48 hours, although it may linger at about 99° F. in the evenings for some days. In children a sudden rise immediately after operation is not uncommon but it usually subsides quickly if a few stitches are removed and the wound is packed open. A continued temperature shows that there is still active infection.

Two superficial conditions are sometimes seen, *erysipelas* and *cellulitis of the scalp.* Both are rare, but are probably more common after early operation. Cellulitis must usually be treated by free incisions, which should not divide the periosteum. *Spreading osteomyelitis of the cranial vault* is a very rare complication of mastoiditis; it can be recognised by the advancing subperiosteal œdema. When it does occur, free excision of the whole infected area of bone is the only possible treatment.

PETROSITIS

Suppuration of the petrous pyramid is a late condition, usually occurring after the third week, and is often first detected after the mastoid operation. It is more common in acute than in chronic mastoid-

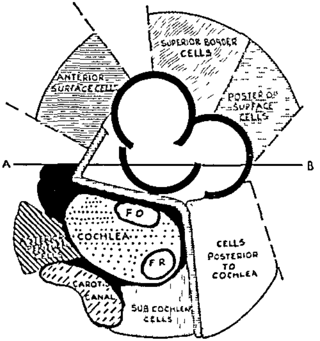


Fig. 2518.—The arrangement of cells in the petrous bone. (*After Myerson, Rubin and Gilbert, by kind permission of the Roy. Soc. Med.*)

itis, and is much more common in cellular than in diploetic bone. The diagram (fig. 2518) shows the arrangement of cells in the petrous bone ; it will be seen that the spread may irritate the labyrinth, which lies

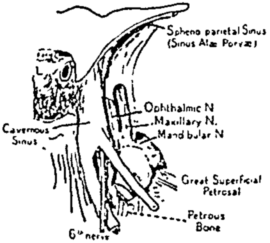


Fig. 2519.—Relations at the apex of the petrous. (*Adapted from J. E. Frazer's "Anatomy of the Human Skeleton."*)

among the cells, disturb the functions of the facial nerve and that if suppuration reaches the upper surface of the pyramid, there will be *irritation* of the fifth nerve, especially the ophthalmic division, and

perhaps paresis of the sixth in Dorello's canal with external rectus palsy (Gradenigo's syndrome) (see fig. 2519). It must not be thought that there is any necessary connection between petrositis and Gradenigo's syndrome. The syndrome may be found without petrositis, and in petrositis the syndrome is rare. The characteristic features of petrositis are the persistent retro-orbital pain, with continued signs of sepsis, persistent discharge, especially from the wound when the tympanum has dried up, and often fluctuating and vague labyrinthine signs.

Treatment of Petrositis

The appearance of signs of petrositis in a patient on whom we have performed an adequate mastoid operation does not compel us forthwith to proceed to further surgical intervention; still less are such signs an indication for immediate exploration of the petrous. If the neuralgia and vertigo are fluctuating but not increasing in severity, and are associated with a free discharge, we may take it that the pus has found a channel of exit and we are justified in waiting, so long as there is no evidence of septicæmia and no signs of meningeal reaction, confirmed, if need be, by lumbar puncture.

We lay particular stress on the importance of a free discharge because in the most dangerous cases of all—the cases of mucosus otitis—there is an ominous absence of discharge. It is in these cases that the radiologist can help us most, for in mucosus otitis the destruction of bone is so disproportionate to the signs, or rather to the absence of signs, that skiagrams are often our only positive evidence of the advance of the infection. The sudden cessation of discharge is a warning sign; it may mean that the wall of the petrous pyramid has been perforated, and that the pus is leaking into an extra-dural abscess. The guiding signs which indicate further intervention are an increase of the local symptoms, evidence of septicæmia and, above all, any signs of meningeal irritation

If we have to operate, what is the right operation to perform? Technically, the approach to the petrous is difficult. The possible routes to the apex of the pyramid are from in front and below or from above. But our object is not to find the apex of the petrous but to find the pus. The apex is an anatomical landmark, the pus is a surgical reality, and the apex is not the only point where the pus can break through into the cranial cavity.

Almour and Kopetzky reach the apex by an anterior route. An extensive radical mastoid operation is performed, and the root of the zygoma and the anterior wall of the bony meatus are cut down until the mouth of the Eustachian tube is exposed. The tensor tympani

muscle and the processus cochleariformis are removed. A 1·5 mm. burr is driven in just posterior to the Eustachian orifice and directly below the tympanic roof at an angle of 20°–25° to the axis of the external auditory meatus. This opens a pyramidal space bounded by the cochlea behind, the carotid canal in front and the Eustachian tube externally. *It has been shown that the carotid canal is separated from* the basal turn of the cochlea by a minimum distance of 6 mm. The apex of the pyramid is below and the base is above; through this space the apex can be reached. The uppermost part of the carotid canal is below the roof of the Eustachian orifice.

In these anterior operations there are great disadvantages, apart from the technical difficulties. It is not a fair objection to say that we should not perform an unnecessary radical operation; the patient's life is at stake, and in any case the amount of hearing which survives a severe petrositis is usually trivial. More valid objections are that the track for exploration is too narrow and that there is no opportunity to inspect the dura; as Almour very fairly points out, his method is not suitable for cases in which the pus has already broken through into the cranial cavity. Another, and a vital, objection is that out of 200 *petrous bones peritubal cells leading to the apex were found in two* specimens only. The best developed cells were those of the anterior surface group, between the facial nerve and the superior canal, and of the subcochlear and posterior cochlear groups.

If, therefore, we cannot find a definite track of infection on exploration, probably our best course is to attack the petrous from above. Frenckner has devised a method of reaching the apex by exposing and defining the arc of the superior canal. Then with a very sharp curette he breaks through the softer bone which fills the concavity of the loop and thus reaches the apex. He has done this in two cases, both times successfully. This method, again, gives a limited approach. The most generally useful procedure is that of Eagleton, which he describes as "unlocking the petrous." The method is fully described in the treatment of meningitis (see page 4674).

CHAPTER IV

Surgery of Chronic Suppurative Otitis Media; Surgery of the Labyrinth; Intra-cranial Complications.

The modern operations for chronic middle ear suppurations are either the "radical mastoid" (tympano-mastoidectomy), which makes a single cavity of the antrum, attic and tympanum, and sacrifices the drum and ossicles, or some modification of this, the so-called "conservative mastoid" operations, in which the tympanic structures are preserved as far as possible. "*Intra-tympanic ossiculectomy*" and the intra-meatal operations on the attic have been abandoned; in the most capable hands they are always dangerous and usually inefficient.

The middle ear suppuration, as distinct from the mucoid discharge which is due to naso-pharyngeal and tubal infection, is the result of osteitis and is characterised by granulations or cholesteatoma or both. The infected area may be sharply limited, as in cholesteatoma of the attic, or may be widespread. Operation, to be successful, must eliminate the whole of the infected bone or the whole of the cholesteatoma, and must provide drainage which will allow permanent epidermisation of the old area of infection. If this is not done the infection will recur. It is probable that the greatest danger to hearing is not the loss of the ossicular chain but scarring and fibrosis around the fenestræ; this would account for the extraordinarily variable degree of hearing in ears on which a radical operation has been performed.

If there are no labyrinthine or intra-cranial complications some definite rules can be laid down:

(1) It is useless to perform any mastoid operation for cases in which there is a large antero-inferior perforation with profuse mucoid discharge. The discharge comes up the Eustachian tube from the nasopharynx, and has nothing to do with the mastoid.

(2) In cases with a central perforation, operation is hardly ever necessary

(3) The radical mastoid operation is easier to do than the modifications, and provides excellent drainage, but it may destroy hearing. A radical operation should never be undertaken on an ear in which there is useful hearing unless there is labyrinthitis or an intra-cranial invasion with extensive necrosis of the roof; as a rule, in such cases the hearing has already gone.

(4) But the presence of an intra-cranial complication other than the above does not *per se* demand a radical mastoid operation.

(5) The weak point in the conservative operations is drainage. If in doubt, do a conservative operation. It is a simple matter to convert it into a radical operation at a later date.

(6) A conservative operation can and should be done on a child, if necessary, as on an adult. It is no more difficult, as the tympanic structures are nearly as large.

INDICATIONS FOR OPERATION IN CHRONIC SUPPURATION

(1) *Operation is absolutely necessary* if there are any signs of intra-cranial invasion or of labyrinthitis; if there is recurrent pain or headache; if there is vertigo; and if there is any acute exacerbation of a chronic condition as shown by pain, tenderness, pyrexia, or any one of these signs.

(2) *Operation will have to be done sooner or later* (and preferably sooner) if there is evidence of cholesteatoma; if there is a fistula in the attic wall or the posterior meatus with discharge of pus or pouting granulations around the orifice; or if there are recurrent polypi or granulations which cannot be controlled by careful local treatment.

(3) *Operation is advisable* in all cases where there is *a persistent discharge of pus* which cannot be cured by careful local treatment and elimination of oral and naso-pharyngeal sepsis. The younger the patient the more important it is to operate early before the structures of the middle ear are irretrievably damaged. For applicants for life insurance, candidates for the fighting services, and patients who intend to travel or who live in remote places the advisability of operation is naturally greater.

As a general rule, it is not much use attempting palliative measures where there is definite attic suppuration or where a perforation in the posterior quadrants of the drum has encroached on the tympanic margin.

GENERAL REMARKS ON OPERATIONS IN CHRONIC SUPPURATION

Chronic suppuration is much more common in acellular mastoids. It was formerly believed that the sclerosis of the mastoid was an inflammatory reaction, a result of the suppuration; it is now generally recognised that this is not so. Two views are held: (1) That the type of mastoid—cellular, diploetic or sclerosed—is an individual peculiarity (Cheatle and Mouret); and (2) That the normal structure is cellular but that the process of cell development is arrested in many cases by intra-uterine or infantile inflammation (Wittmaack). The former is more

generally accepted. In either case the structure of the mastoid is the *cause* rather than the effect of the chronicity, as suppuration progresses quietly in an insensitive bony cavity where the thick walls prevent the periosteal reaction which betrays inflammation in a thin-walled cellular mastoid. When chronic suppuration is found in a cellular mastoid it is usually either an empyema in a mastoid with cells but with a thick cortex, or it is not, strictly speaking, a mastoiditis but a localised attic infection with little damage to the mastoid antrum and cells. In the first type of case, which is more common in children, the condition can often be cured by a well-executed Schwartze operation without interfering with the middle ear; in cases of the second type, very little may be found in the antrum, but when the attic is opened the incus may be seen lying loose in a bed of granulation tissue and cholesteatoma. *Sequestra* are not often found in chronic suppuration.

Skiagrams sometimes give useful information as to the presence of cholesteatoma, but their evidence is not yet reliable, especially in attic cases.

How is hearing best preserved? The earlier operation is done the better is the prognosis. It is a clinical observation, for which there is no adequate physiological explanation, that *preservation of the ossicular chain* is not an *absolute* essential for useful hearing. There is no justification for interfering with the ossicles if this can be avoided, but in some attic cases with good hearing we find a loose, necrotic incus. Under these circumstances it should be removed, but before doing so we must be sure that it really is loose.

DIFFICULTIES AND DANGERS OF THE RADICAL OPERATION

To experienced aural surgeons the radical mastoid is very much a "set" operation, and the situation is well summed up by a colleague who said: "The more radicals I do the quicker I do them; the more Schwartzes I do the longer I take over them." But until the anatomy of the region and the minutiæ of technique are perfectly familiar this is not the case. The dangers are quite real: (1) We are working over the track of the facial nerve, not behind it as in the Schwartze operation. (2) We are in much closer contact with the wall of the labyrinth. (3) We approach the dura of the middle fossa at an awkward angle. (4) In most cases we are working on a dense sclerotic mastoid, with the deep antrum and "forward" sinus which so often occur in a mastoid of this structure.

THE RADICAL OPERATION

Preparation, *anæsthesia*, and *position* of patient and team are the same as for the acute mastoid operation (see page 4632).

Instruments. As for the acute mastoid (see page 4636) with the addition of two chisels, ¼-inch and ⅜-inch wide.

(1) Incision as for the acute mastoid, but a shade closer in to the retro-auricular groove. Define the landmarks, and then with a strip of gauze in forceps carefully detach the soft meatus from the bone. If this is done gently it is possible to strip the whole of the skin from the posterior and superior walls intact right down to the tympanic ring. The more completely this is done the easier will it be to make a good plastic flap at the end of the operation. Pack a strip of ribbon gauze between the soft structures and the bony wall.

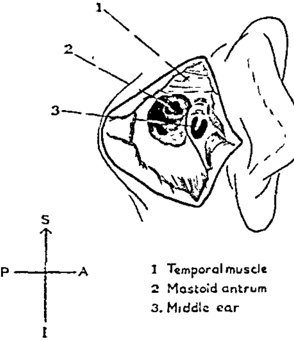


Fig 2520.—The radical operation begun. Antrum and middle ear separated by posterior wall of the bony meatus.
(*After Hautant*)

(2) The orthodox method is to open the antrum from behind the bony meatal wall, as in the Schwartze operation. This leaves two bony cavities, the antrum and the middle ear, separated by a bony partition at the bottom of which is a tunnel of communication, the aditus. The bony partition must now be cut away in order to convert the tunnel into a trench.

(3) The posterior bony wall of the meatus and the outer wall of the attic must be cut away in order to do this. First, with a small gouge get the fullest possible exposure of the aditus. Then attack the posterior meatal wall. For this the ⅜-inch chisel is better than a gouge,

as it holds more firmly to the bone. Mark the aditus and make a cut with the chisel, at the level of the upper boundary of the aditus, in the posterior wall. The chisel should be laid with the edge parallel to the tegmen and the bevel downwards, and be driven directly inwards for $\frac{1}{4}$-inch with a single light tap of the mallet. Then lay the chisel, bevel upwards, on the posterior wall $\frac{1}{2}$-inch below the first cut, and drive it upwards and inwards to meet the first cut. This frees a shaving of posterior wall. Throughout this stage never forget the facial nerve; we get nearer to it at each cut, and the anæsthetist should be told to watch the facial muscles for the slightest twitch. There is a little artery in the posterior wall close to the Fallopian aqueduct, and if this artery is encountered it warns us that we have gone quite deep enough. With this in mind, continue the alternate cuts until nothing but the

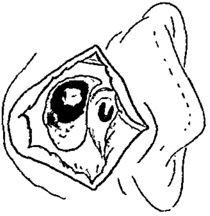


Fig 2521.—RADICAL MASTOID OPERATION. THE OUTER ATTIC WALL HAS BEEN ATTACKED FROM BEHIND AND THE REGION OF THE ADITUS MORE FULLY EXPOSED. (*After Hautant.*)

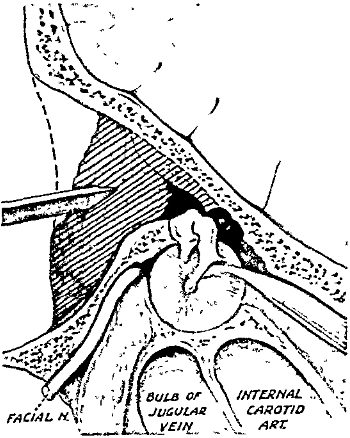
"bridge," an arch of bone about $\frac{1}{8}$-inch thick, separates us from the aditus.

(4) Theoretically, this is the most dangerous part of the operation. A slip of the chisel might tear the dura or divide the facial nerve; a sudden plunge might open the external canal. In practice, all these catastrophies are improbable. Damage is usually done when the greatest difficulties have been mastered and the operator relaxes his watchfulness. *Do not* rely on artificial aids. The worst and most dangerous of these is the "Stacke guide" which is supposed to protect the facial nerve. We are advised to put this instrument into the aditus and to "cut down on it"; the result of this advice has sometimes been that the protector itself has been driven into the Fallopian aqueduct with disastrous results. Nearly as bad is the practice of cutting away the bridge with bone forceps. With the chisel very firmly held, three light cuts in order, one above, one a little forward over the centre of the tympanic cavity, and one below towards

the aditus, will free the outer attic wall and open the aditus. The *sensation of "cracking" at the third cut announces that the division is complete.*

(5) If the wedge-shaped piece of bone (the outer wall of the aditus and attic), which has been freed by the chisel cuts, falls into the cavity of the attic it may jam there. If this happens *do not* grub for it with a curette or try to extract it with a hard tug of the forceps; carefully cut away a little more of the *roof* until the loose piece can be picked up

Fig 2522.—Radical mastoid operation. Removal of the posterior meatal wall showing relations of the facial nerve.



with forceps and lifted out. The antrum, aditus and attic are now a single cavity.

(6) Pack into the attic a piece of ribbon gauze, 1 inch square, soaked in adrenalin. (Do not forget that there is already a piece of gauze in the meatus.) Carefully clear all the overhanging edges of the roof and outer attic wall; a small gouge is best for this.

(7) Take out the gauze packs from the meatus and attic. Loop a doubled piece of ribbon gauze, 1 foot long, through the detached soft meatus and pull it forwards to get a full view of the middle ear. (It is sometimes recommended to perform the plastic operation on the soft

meatus at this stage. This ought to give an excellent view of the middle ear, but unfortunately *there is generally so much oozing* after doing the plastic part of the procedure that the field is flooded; it is usually better to make it the final stage of the operation.) Remove from the attic all traces of polypus or cholesteatoma. Identify the *body of the incus* and the *head of the malleus* above, and the *remains of the tympanic membrane* below. (In long-standing suppuration the incus may be entirely destroyed and the malleus reduced to a bead of bone.)

(8) Remove the malleus and incus with aural forceps. Then with forceps, *not* with a curette, remove the last traces of the tympanic membrane, and inspect the inner wall. Identify: the bulge of the *promontory*, which is the basal turn of the cochlea; in front and above this, the opening of the *Eustachian tube*; and behind and below,

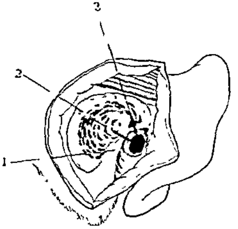


Fig 2523.—Radical mastoid operation. Detail of removal of the "bridge."

The posterior meatal wall (1) has been cut down until only the bridge of bone between (2) and (3) is left arching over the aditus. This is now divided with chisel cuts and removed.

(*After Hautant*)

the *recess of the round window*. The *region of the oval window and the stapes* lies above and behind the promontory, between it and the ridge that marks the horizontal part of the Fallopian aqueduct. This region is usually obscured by the posterior meatal wall. It is not necessary to expose it unless we wish to open the labyrinth, and if it is exposed in an ordinary radical operation it must be religiously left alone. Gently remove any granulations from the inner wall with gauze. *Never* curette the inner wall; the facial nerve, the labyrinth and the carotid canal are all in danger.

(9) Cautiously trim down the posterior meatal wall with the chisel until the aditus and middle ear cavity are freely open without "overhangs." When this is being done the anæsthetist must keep watch on the facial muscles for any twitching.

(10) Various ingenious methods have been described for closing the orifice of the Eustachian canal. Generally, they are impracticable or

useless, or both; if there is no active naso-pharyngeal infection, there is no need to occlude the orifice; if there is infection, no attempt at occlusion can succeed.

(11) The plastic operation on the meatus. It is advisable to do a plastic operation in all cases. Occasionally, when the mastoid cavity is very small, an excellent result is obtained by packing the meatus *without doing any plastic enlargement. Unfortunately it is* the experience of the majority of aural surgeons that these cases are exceptional; as a rule, however good the immediate result may be, the end-result is disappointing, and a plastic operation has to be done later. If there is an acutely septic exacerbation, or if we are compelled to do a radical operation on a patient with an infected and eczematous meatus, it is

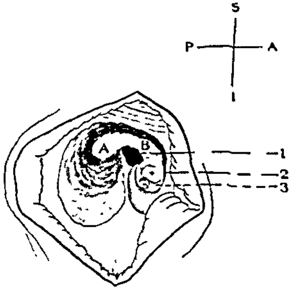


Fig. 2524.—THE RADICAL OPERATION COMPLETED. THE MASTOID ANTRUM (A), ATTIC (B) AND TYMPANUM ARE THROWN INTO A SINGLE CAVITY

(1) The smoothed-down posterior meatal wall.
(2) The promontory.
(3) The recess of the round window

The plastic operation on the meatus has not yet been done

(*After Hautant*)

often wise to perform the radical operation on the bone first, pack the cavity widely open from behind, and some weeks later carry out the plastic procedure on the meatus.

The object of the plastic operation is to enlarge the meatal opening, so as to give free access to the cavity, and to provide as much skin covering as possible for the exposed surface of bone. There are a dozen *methods of fashioning the flap. The simplest is to make a single up- or* down—flap of the whole of the posterior soft meatal wall. To make the "up-turned" flap, pass a round-ended tenotomy knife into the meatus and draw it out, edge down, along the floor. At the orifice, without *lifting the blade, turn it backwards and outwards and carry it with a* sawing movement into the concha and upwards towards the crus helicis. This gives a roughly rectangular flap hinged upwards. Secure the bleeding points, especially the posterior auricular artery, remove as

much of the cartilage as possible from the flap, and secure it with a couple of catgut stitches.

(12) Grafting the cavity. *Skin grafts* have been used to promote epidermatisation of the cavity. The usual Thiersch graft is cut from the inner surface of the thigh, and laid over the region of the aditus and the inner tympanic wall. It is adjusted with aural forceps and coaxed into position with a greased pack. Skin-grafting must never be used: (*a*) if there is any suspicion of an intra-cranial lesion; (*b*) if there is a labyrinth fistula; (*c*) in acute exacerbations of chronic infections; or (*d*) over exposed dura. *Grafts of periosteum* or of *muscle* (temporal or sterno-mastoid) have been used to obliterate the cavity. The contra-indications are the same as in the case of skin grafts. When periosteum or muscle is used, the graft is made with a flap of the structure which must not be entirely detached. The greatest difficulty with the muscle flap is a tendency to oozing. On the whole, although some surgeons have had excellent results, the applicability of the method is limited.

(13) Close the post-aural incision with silkworm-gut sutures.

(14) Pack the cavity with a strip of 1-inch ribbon gauze soaked in 2 per cent oily flavine, and cover with a large dressing.

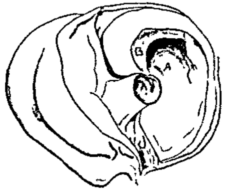
After-Treatment. There is usually little post-operative pain. The outer dressing should be changed during the first forty-eight hours. If the temperature is normal, the pack can be left in for ten days. Do not hesitate to give gas for removal of the pack if it is very painful. Inspect the cavity carefully with a headlight and speculum, paying particular attention to the region of the aditus and antrum; it is in this region that "pockets" are most likely to form. If granulations are exuberant, paint them with 50 per cent silver nitrate, and put a small pack of gauze in flavine into the antrum and aditus. After the first pack has been removed, the less the tympanum is packed the better. If the cavity is healing well the whole cavity can be filled with ambrine, poured in at just a high enough temperature to melt it. The ambrine can be removed and a fresh dose put in eight days later. Prolonged packing is to be avoided unless contraction of the cavity is feared.

MODIFICATIONS OF THE RADICAL OPERATION

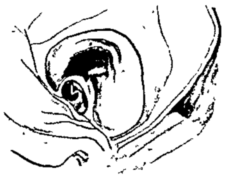
In some cases where the antrum is small and deep with a forward lateral sinus and an overlapping middle fossa, the best approach is through the postero-superior angle of the meatus, as previously described for acute cases where these anatomical difficulties are present. The radical operation is then completed in the usual way.

The *conservative mastoid operations* are intermediate between the Schwartze and the radical. The object is to leave as much as possible of the middle ear intact. The best is the "epitympano-mastoid"

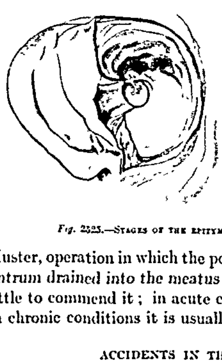
or "transmastoid atticotomy." This operation should always be done in cases of attic suppuration with useful hearing. The operation is started in the usual way until the antrum and aditus are fully exposed. Then the outer attic wall is cut away with a small gouge, and lastly the posterior meatal wall is cut down, and the flap cut. The stages of the operation are shown in the diagrams (fig. 2525). The Heath, or



(1) The antrum has been opened. The external canal (A) is seen in the floor of the aditus, and part of the aditus-attic wall has been cut away (B).



(2) The attic is now open and the posterior meatal wall has been cut down, but there is still a bridge of bone covering in the ossicles and the upper border of the tympanic membrane.



(3) The antrum, aditus and attic form a single space. The malleus and incus are seen lying undisturbed at the upper boundary of the tympanic membrane. The operation is completed by making a plastic flap of the soft meatus as in the radical.

Fig. 2525.—STAGES OF THE EPITYMPANO-MASTOID OPERATION. (*After Sourdille.*)

Kuster, operation in which the posterior meatal wall is cut away and the antrum drained into the meatus without removal of the attic wall, has little to commend it; in acute conditions it is seldom necessary, while in chronic conditions it is usually inadequate.

ACCIDENTS IN THE RADICAL OPERATION

(1) *Injury to the labyrinth.* The external canal has occasionally been injured. In most cases where this has happened there have been

no serious consequences; the vertigo has ceased after a few days and there has been no evidence of permanent damage to the labyrinth. In rare instances labyrinthitis has followed. *Dislocation of the stapes* is much more serious. If the stapes is dislocated *into the operation cavity*, the best course is to watch the patient closely for several days and to drain the labyrinth if and when evidence of labyrinth suppuration appears; if the stapes is forced *into the labyrinth*, vestibulotomy must be performed immediately and the stapes found and removed. If this is not done, labyrinth suppuration is inevitable and meningitis is probable.

If there is any suspicion that the labyrinth has been injured during the operation, the cavity must not be grafted, and should be very lightly packed.

(2) *Injury to the carotid artery.* This accident is, fortunately, very rare. If it does occur it is always associated with necrosis of the inner tympanic wall. The bleeding must be arrested by firm packing into the cavity, this being held by the assistant's finger; the internal carotid is then exposed and ligated in the neck. It is well to ligate the internal jugular at the same time. The operator then returns to the mastoid wound, cautiously enlarges the hole in the bone of the carotid canal, and obliterates the vessel in the canal with packing.

(3) *Injury to the facial nerve* (see page 4687).

SOME GENERAL REMARKS

(1) A radical mastoid cavity will never heal satisfactorily if there is active oral or naso-pharyngeal sepsis. If there is no urgent indication, do not attempt the radical operation until septic teeth and tonsils have been removed and any infected paranasal sinus has been drained.

(2) The better the operative technique the less trouble will there be in the after-treatment; but the best operation can be spoilt by careless after-treatment.

(3) It is easy enough to do a radical operation of a sort, but it is never easy to do a good radical operation; the results of a bad one may be very bad indeed.

Surgery of the Labyrinth

LABYRINTHINE SUPPURATION

For practical purposes pyogenic labyrinthitis is the result of middle ear suppuration; in rare instances it follows injury, such as an operation accident or fracture of the *basis cranii*. Other causes of suppuration in the labyrinth are surgical curiosities.

Labyrinthitis is important surgically only because it may invade

the cranial cavity: (1) By the internal auditory meatus into the subarachnoid space and the cisterna pontis; (2) By the aqueduct of the cochlea (ductus perilymphaticus) by which the perilymph passes into the cerebro-spinal fluid in the posterior fossa; (3) By the aqueduct of the vestibule through or alongside the ductus endolymphaticus; or (4) By necrosis of the bony wall of the labyrinth.

Extension by routes 1 and 2 causes meningitis, by 3 and 4, abscess either extra-dural, inter-dural, or cerebellar (fig. 2526).

The functional changes in the labyrinth are surgically important only because they indicate the progress of invasion, and by that the danger to the meninges. The labyrinth is so small, and the nerve-endings are so close together that diffuse suppuration must rapidly destroy them and abolish all activity. Thus, so long as the labyrinth preserves any activity, the invasion of the perilymphatic space cannot be complete and the danger to the meninges is small. On the other hand, if the labyrinth is completely inactive in a suppurating ear we can assume that it has been destroyed by infection and is itself infected.

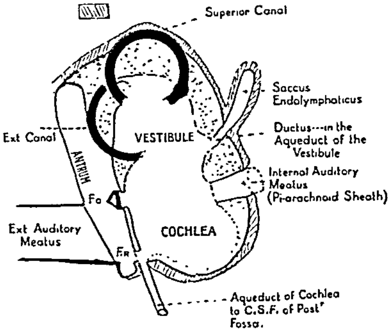


Fig. 2526.—THE PATHS OF SPREAD OF INFECTION FROM THE LABYRINTH.

= Dura mater.

Extension by *erosion of bone* will cause an *extra-dural* abscess. So, too, will extension *along the side of* the ductus endolymphaticus; but extension *into* the ductus or saccus will first cause an *intra-dural* abscess. Extension through the internal auditory meatus or the aqueduct of the cochlea is directly into the subarachnoid space of the posterior fossa.

(*Watlyn-Thomas and Yates*)

Giddiness in the presence of aural suppuration must always be taken seriously. If the labyrinth is affected, giddiness is usually accompanied by nystagmus, unsteadiness of gait and, in severe cases, by vomiting. The violence of the vomiting may mask the other signs, which explains the fact that cases of fulminating labyrinthitis are sometimes treated as "gastric influenza."

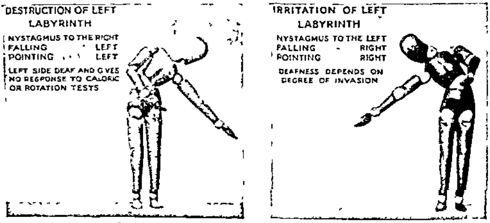
Unnecessary confusion has been caused by the nomenclature of

labyrinthitis: (1) "Circumscribed labyrinthitis" or "labyrinth fistula" is, strictly speaking, neither labyrinthitis nor a fistula; it is an erosion of the bony wall which exposes the endosteum and makes the labyrinth abnormally sensitive to changes in pressure or temperature; (2) Serous labyrinthitis is a sympathetic effusion, caused by inflammation in the middle ear; (3) Suppurative labyrinthitis is classified as "manifest" or "latent." "Latent" labyrinthitis means that the labyrinth has been destroyed by suppuration and that since the destruction the labyrinth of the sound side has compensated for the loss of function; there are, therefore, no obvious signs of any labyrinth disturbance.

THE LABYRINTH TESTS AND DIAGNOSIS

The tests of labyrinth function are based on these facts:

(1) The nerve-endings of the labyrinth are in a state of tonic



A B

Fig. 2527.

activity, and send to the higher centres a continuous stream of impulses which maintain equilibrium.

(2) Normally the labyrinths of both sides are equally active. An increase in the activity of one side produces involuntary movements *towards the less active side.* These movements are:

(*a*) The slow movement of nystagmus.

(*b*) Swaying and falling.

(*c*) Deviation of the finger when pointing with eyes shut.

(*Note.* Nystagmus is a double movement, slow in one direction, and quick in the other. The labyrinthine component is the slow movement, but the quick movement or "movement of return" is the more easily detected, and therefore the nystagmus is described according to the direction of the quick movement, which is confusing.)

If one labyrinth is destroyed the sound side is, of course, the active side, and all movements are towards the side of the destroyed labyrinth (fig. 2527).

The labyrinth tests are of great scientific interest, but for surgical purposes we want to know two things: (*a*) Is the labyrinth still active? and (*b*) If it is active, is the wall intact? If the labyrinth has been destroyed *hearing will be lost.* To prove loss of hearing the good ear must be completely deafened by the Bárány noise machine or by syringing during the test. The most reliable test for the labyrinth is the *caloric test.* This is based on the fact that irrigation with fluid

TABLE OF SIGNS OF SUPPURATIVE LABYRINTHITIS
(*After Ruttin*)

	Preceding Vertigo.	Accompanying Vertigo and Tinnitus.	Spontaneous Nystagmus. To healthy side.	Spontaneous Nystagmus. To diseased side.	Rotation Test.	Caloric Test.	Fistula Sign.	Hearing.
Circumscribed Labyrinthitis	+ in crises	+	or		+	+	+	+
Serous Labyrinthitis . .	+	+	then		±	diminished	+ or 0	+ or —
Destructive Labyrinthitis .	+ or 0	+			0	0	0	0
Latent Labyrinthitis .	+ or 0	0 or slight	slight or absent		+ compensation	0	0	0

a few degrees above or below 98° F. causes nystagmus and giddiness. *The best working explanation of the test is that, if the temperature of* the labyrinth fluid is altered, a current is set up which stimulates the nerve-endings. The test can also be done with cooled air, using Dundas-Grant's instrument. If there is no giddiness or nystagmus after 3 minutes' syringing with cold water and there is absolute unilateral deafness to the voice and to a tuning-fork on the mastoid, we can assume that the labyrinth is inactive.

If the middle ear is full of granulations, the cold water cannot reach the labyrinth wall, and the test may fail. In this case it is well to do the mastoid operation and at the end of the operation to douche the cavity with ice-cold saline. The slow movement of nystagmus is not abolished

by light anæsthesia, and if the labyrinth is active there will be a deviation of the eyes towards the irrigated side, which can be reversed by irrigating with hot lotion.

If there is an erosion of the wall of an active labyrinth, the fistula sign is usually present. When the pressure in the ear is suddenly raised, for instance, by pressing firmly on the tragus, if there is an erosion of the labyrinth wall the pressure is transmitted directly to the labyrinth fluids and there is nystagmus and vertigo.

SUMMARY

In "*circumscribed labyrinthitis*" or "*labyrinth fistula*" the labyrinth is unduly sensitive. Hearing varies according to the amount of middle ear destruction, the response to the labyrinth tests is excessive, and the fistula sign is present.

In "*serous labyrinthitis*" the affected labyrinth responds, often only slightly, to the tests and there are traces of hearing.

In "*suppurative labyrinthitis*" there is no survival of hearing or of labyrinth activity.

TREATMENT OF LABYRINTHITIS

(1) *Circumscribed labyrinthitis.* The appropriate mastoid operation, Schwartze, conservative or radical according to the ordinary rules for a mastoid operation, should be performed and the "fistula" exposed. The fistula must not be curetted or probed or interfered with in any way at all. In the great majority of cases, once the mastoid suppuration has been cured the fistula heals completely. In exceptional cases, it does not heal and causes continual attacks of vertigo. Only under these circumstances, and then only after a considerable interval, are we justified in destroying the labyrinth.

(2) *Serous labyrinthitis.* No operation should be done on the labyrinth. No operation should be performed on the mastoid, if it can possibly be delayed, until all signs of labyrinth irritation have subsided.

(3) *Manifest suppurative labyrinthitis.* If there are signs of labyrinth destruction, vertigo, falling, and pointing error to the affected side, with violent nystagmus (quick movement to the sound side, slow to the affected side) and complete loss of hearing and labyrinth function, it is advisable to open and drain the labyrinth without further delay. Some surgeons advise that the labyrinth should not be drained unless there are signs of meningeal irritation, headache, or an increase in the cells of the cerebro-spinal fluid. The danger of this is that the invasion of the meninges may be very sudden, and once the meninges are invaded the

danger is enormously increased. It is important to remember that often there is little or no pyrexia in labyrinthitis until the meningeal reaction begins.

(4) *Latent labyrinthitis.* If the labyrinth has been destroyed by infection there may be danger to the meninges although there are no labyrinth signs except total loss of excitability. The treatment depends on the degree of repair. If the ear still suppurates, a radical mastoid operation should be carried out, and the labyrinth should be drained

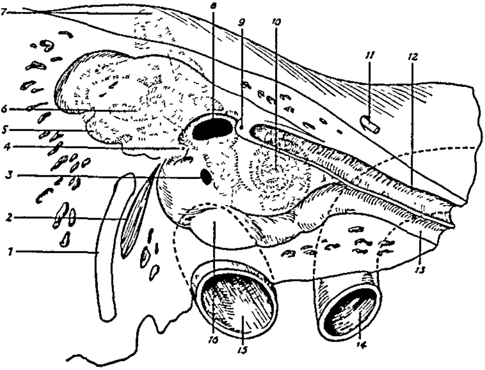


Fig 2528.—Inner tympanic wall.

(1) Facial nerve, (2) stapedius, (3) fenestra rotunda, (4) pyramid and stapedius tendon, (5) mastoid antrum; (6) horizontal canal; (7) superior canal; (8) fenestra ovalis; (9) "pulley" of tensor tympani; (10) promontory, (11) great superficial petrosal, (12) canal of tensor tympani, (13) Eustachian tube; (14) carotid artery, (15) jugular vein, (16) bulge in tympanic floor over jugular bulb. The labyrinth is indicated by dotted shading

(*Adapted from Denker and Kahler's Handbuch. Corning*)

unless it is completely shut off by scar tissue. A mastoid operation in the presence of active labyrinthine suppuration, however chronic, may set up meningitis unless the labyrinth is drained at the same time. For this reason particularly a radical operation should never be done without preliminary investigation of the labyrinth.

In some cases necrosis of the labyrinth has occurred, and it will then be necessary to remove the sequestra. The facial nerve has probably been already destroyed by suppuration, but, if not, great care must be taken to avoid damaging it. As a rule, the necrosed

labyrinth can be removed in two pieces, a sequestrum of the canals behind the facial nerve, and a fragment of the cochlea in the middle ear. Sometimes the carotid canal is open, and this possibility must always be remembered.

DRAINAGE OF THE LABYRINTH—LABYRINTHOTOMY

The simplest operation is the " vestibulotomy " of West and Scott.

Instruments. As for radical mastoid. with, in addition, straight, narrow labyrinth chisels and gouges, a fine-pointed labyrinth probe and a labyrinth curette. The von Eicken binocular magnifying loupe is very useful. A suction apparatus with fine nozzles should be available. Iced saline should be kept ready, as it checks oozing more efficiently than adrenalin. The chisels and gouges must be very sharp, or the bone may be split. not cut. with disastrous results to the facial nerve.

First stage. Radical Mastoid Operation. This must be more extensive than usual; enough posterior meatal wall must be cut away to show the oval window and the recess of the round window. If necessary some of the meatal floor must be removed. Cutting the meatal flap at this stage gives more room, but the oozing from the cut edges is so troublesome that it is better to pull the soft meatus out of the way by looping a strip of gauze through it.

Second stage Inferior Vestibulotomy. The following landmarks should be identified . (1) Facial ridge above the oval window ; (2) bulge of the horizontal canal ; (3) promontory, corresponding with the first turn of the cochlea ; (4) the oval window ; and (5) the recess of the round window. With a few light cuts of the chisel the bar of bone between the recesses of the windows is divided and the posterior part of the promontory cut away. The triangular piece of bone so freed is gently lifted out. This opens the vestibule and the basal turn of the cochlea. Take out the stapes and then cautiously extend the opening forwards and downwards until the windows, vestibule and basal turn of the cochlea form a single cavity. Upward extension endangers the horizontal part of the facial nerve ; backward extension the descending part. Avoid injuring the deep wall or the modiolus of the cochlea, as this opens the internal auditory meatus. This accident is not really dangerous, but the flood of cerebro-spinal fluid adds greatly to the difficulties.

Third stage. Superior Vestibulotomy. Identify the bulge of the horizontal canal behind the facial ridge in the region of the aditus. If there is a fistula, enlarge it with chisel cuts, first backwards and then

forwards to the ampulla. If there is no fistula, open the canal as far back as it can be traced with a few cautious chisel cuts, and then enlarge by opening backwards and forwards. Remove the bone above the ampulla, and so open the ampulla of the superior canal. Very carefully chip away the bone between the two ampullæ. The vestibule is now open from above as well as from in front. Arching over the cavity between the two gaps made by the operation is a " flying buttress " of bone which contains the facial nerve in its canal.

Fourth stage. A meatal flap is cut and the wound closed behind. No packing should be put into the cavity.

There are several methods of opening the labyrinth, which will not here be discussed in detail. The operation of West and Scott is technically the easiest and gives perfectly adequate drainage. If there is any evidence of meningeal infection due to labyrinthitis, it is not difficult to complete the operation by establishing *trans-labyrinthine drainage.*

OPERATIONS ON THE LABYRINTH FOR VERTIGO

(1) In a very small number of cases of intractable labyrinthine vertigo (Ménière's syndrome) where all other methods of treatment have failed, it is justifiable to operate on the labyrinth as a last resort. The general principles of treatment are here outlined :

(*a*) The indications are entirely different from those in suppurative labyrinthitis. There we operate because the patient's life is in danger, and the operation is less dangerous than the disease.

In Ménière's syndrome the patient's life may be miserable, but it is not in danger until we operate. The risk is slight, but it is real. The operation is more dangerous than the disease.

(*b*) The risk is infection of the labyrinth from the middle ear and through it of the meninges ; therefore it is better, if possible, to operate from behind the tympanic cavity rather than across it.

(*c*) Operations are of three kinds :

(i) Those designed to compensate pressure changes by the formation of a " safety valve." These are based on the view that the vertigo is due to a " glaucoma " of the labyrinth, and are analogous in principle with corneo-sclerotic trephining. Examples of these operations are the *formation of a fistula on the external canal* and Portmann's operation for *draining the saccus endolymphaticus.*

(ii) Destruction of the labyrinth by vestibulotomy, or injection of alcohol.

(iii) Division of the eighth nerve. This operation has been advocated on the grounds that no other treatment has been of any benefit in

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Ménière's syndrome, which is not true, and that "true" Ménière's syndrome is due to changes in the eighth nerve, which has not been proved. The operation is certainly more severe than alcohol injection or vestibulotomy, and necessitates a large decompression.

(2) Occasionally a labyrinth erosion does not heal in spite of an adequate and successful mastoid operation, and the persistent vertigo is unendurable. In such a case, when all else fails, it is justifiable to destroy the labyrinth. The best and simplest way of doing this is by an alcohol injection through the fistula.

OPERATION ON THE LABYRINTH FOR TINNITUS

This seems quite unjustifiable, and should never be done. Tinnitus is often found in patients after labyrinthotomy for suppurative labyrinthitis, and tinnitus has persisted after division of the eighth nerve.

OPERATIONS ON THE LABYRINTH FOR OTOSCLEROSIS

Attempts have been made to restore hearing in cases of otosclerosis, when the stapes is immobilised, by making an artificial fenestra on the promontory or on the external canal. In many cases there has been immediate improvement in hearing, but, unfortunately, this improvement is usually transitory. After a few weeks, sometimes a few months, the patient is as deaf as ever. This relapse has been attributed to the closing of the fenestra by newly-formed bone, and recently Sourdille and Holmgren have suggested methods by which this can be obviated. At present these operations are still in an experimental stage.

OTOGENOUS INFECTION OF THE LATERAL SINUS

This condition is usually called "lateral sinus thrombosis," but the description is unfortunate because it confuses the issue. Surgically the important thing is the infection of the blood clot, not the clotting of the blood.

In the great majority of cases of sinus infection the cause is a mastoid infection which erodes the bone and invades the sinus groove. Then, either: (1) by direct contact with the infected bone there is pachymeningitis and invasion of the sinus through the blood-vessels in its own wall; or (2) there is an extra-dural peri-sinus abscess, which is followed by pachymeningitis. In both cases there is inflammatory reaction of the endothelium with deposit of fibrin on the vessel wall; this is the "mural clot." If the defence is entirely adequate, the clot becomes organised; there is no invasion of the blood stream, and no clinical evidence of the condition. If the resistance is not adequate, invasion of the blood stream and septicæmia may occur without further throm-

bosis, or more and more fibrin is deposited until thrombosis is complete and the sinus is occluded. If the source of infection is removed and the resistance is now adequate again, as with the mural clot, the thrombus becomes organised; later it is canalised and the lumen of the sinus is restored without any clinical evidence of thrombosis ever having occurred. This certainly happens, but it is unusual.

Generally, the clot is softened by infection; small pieces break away, are carried off by the blood stream and cause septico-pyæmia with, perhaps, infarction of the lung, empyema, or lung abscess; empyema is the most common. Also particles of infected clot may lodge in small vessels and cause metastatic abscesses. The commonest places for these are around joints; less frequently, actually in them. Infection of the kidney is unusual except in children, where we must always be on the watch for pyuria.

Meantime, the clot may grow backwards into the torcula and so into the longitudinal or the straight sinus, or by the superior petrosal sinus into the cavernous sinus. *The common extension is downwards to the jugular bulb and so into the jugular vein.*

Besides the spread along the vessels and into the blood stream, the infection may invade the subarachnoid space, causing meningitis, or it may advance along the veins, passing from the cerebellum into the sinus and so cause cerebellar abscess.

Unusual causes of septic thrombosis are: (1) *Infection and thrombosis of a mastoid emissary vein* with retrograde extension into the sinus; (2) *labyrinthitis* with necrosis of the wall and extra-dural abscess, or abscess of the saccus endolymphaticus; and (3) *operation injuries.*

Some Statistics

The condition is not uncommon. The incidence is roughly one in two hundred cases of otitis media. Except for extra-dural abscess, it is the commonest intra-cranial complication. The most common age incidence is the second and third decades. It is slightly more common in males, slightly more common on the right side, and equally common in acute and chronic otitis. If cases are included in which there is a complication such as meningitis or cerebellar abscess, which may be secondary to the sinus infection, the death-rate is nearly 40 per cent.

Signs and Symptoms

The classical signs of an intra-cranial lesion—headache, vomiting and papillœdema—are not to be relied on in sinus thrombosis, as there is usually little rise of intra-cranial pressure. There may be headache, but it is rarely severe unless there is an extra-dural abscess; engorgement

of the disc is found in only a minority of cases; while vomiting suggests a further intra-cranial complication. The most reliable sign is pyrexia. A rigor is valuable confirmatory evidence, but we must never wait for a rigor. If the temperature is 101° or over in an adult with mastoiditis, a blood infection should be suspected, and the sinus wall exposed and examined. The text-book signs of a " cord in the neck " or tenderness in the neck are not much help. The thickening and tenderness are due to inflamed lymphatic glands, but the glands may be inflamed without any sinus disease, and the jugular vein may be thrombosed far down into the neck without any infection of the glands.

A blood count may help, but the leucocytosis may be due to mastoiditis, not to sinus thrombosis. A positive blood culture is sometimes obtained, but a blood culture is of no use unless the blood is taken at a pyrexial peak; generally we have positive clinical evidence before we have a positive blood culture.

Evidence from Inspection of the Sinus

The suspected sinus is exposed. Is it thrombosed? The normal sinus is bluish, with a thin elastic wall on which fine blood-vessels are seen. When the sinus is compressed lightly with the finger it empties below the point of pressure, and fills as soon as pressure is released. Pulsation is transmitted from the brain, and a respiratory wave can often be seen.

(1) The sinus wall is discoloured, from greyish-green to black. It may be gangrenous, with pus oozing through the ulcerated surface. The diagnosis is obvious: the sinus is thrombosed.

(2) The sinus is distended and lies like a white raised band on the dural surface. It is resistant to palpation (but palpate *very gently* so as not to dislodge the clot!), and exposure far enough back shows a normal blue wall. The sinus is thrombosed.

(3) There is an extra-dural abscess with healthy red granulations on the sinus wall. In this case there is a good chance that the barrier is adequate, and we are justified in exposing the sinus wall and waiting for a day or two to see whether the symptoms will subside before attacking the sinus.

(4) The sinus appears healthy except for one thickened white area. If there is evidence of blood infection we are justified in regarding this as an infected sinus and dealing with it as such.

Some Difficulties

(1) It is always easier to diagnose thrombosis from the appearance of the sinus when it is first exposed than after it has been exposed in a

mastoid wound for a few days, as it will then be covered by a thick coat of exudate.

(2) Both ears are discharging, and there is clinical evidence of sinus infection, but no evidence as to which side is to blame. We may be driven to open both mastoids and to expose both sinuses, but in a very sick patient this is a formidable undertaking and it is worth while trying the Lillie-Crow or the Tobey-Ayer test. These depend on the fact that if one sinus is occluded the main venous drainage will be by the *opposite* sinus and jugular vein. If that jugular is temporarily occluded by digital pressure, there will be an immediate rise of intracranial venous pressure with a corresponding rise of pressure in the cerebro-spinal fluid (Tobey-Ayer), and venous engorgement of the optic discs (Lillie-Crow). *Example:* There is thrombosis of the right lateral sinus. A lumbar puncture is made and the needle connected with the manometer. The right jugular vein is compressed; the pressure in the manometer is unchanged. The left jugular is compressed; the pressure of cerebro-spinal fluid immediately rises because the main venous exit has been occluded (Tobey-Ayer). At the same time the veins about the optic disc, unchanged by the pressure on the right jugular, are seen to fill as soon as the left jugular is compressed (Lillie-Crow).

Demonstration of the thrombus by X-ray examination after injection of a soluble radio-opaque substance has been described, but the method is in the experimental stage and is not yet applicable clinically.

(3) The sinus is exposed and the appearance is suspicious but inconclusive. If on clinical grounds we are convinced that the sinus is thrombosed, we should treat it as thrombosed and operate. If we are doubtful and have relied on the appearance of the sinus to convince us, it is better to wait. Sticking hypodermic needles into the sinus "to test for thrombosis" is unreliable and dangerous. The needle may penetrate a mural clot and find free blood, or the slight extra damage of the puncture may infect an uninfected sinus.

(4) Can a patient survive ligation of both jugulars? Patients have survived without any ill-effect when there has been an interval of a week to a fortnight between the two operations, but such cases are surgical curiosities; the risk is enormous.

(5) Septicæmia without thrombosis.

If septicæmia is present but there is no evidence of thrombosis, the sinus should not be disturbed. Scrupulous removal of infected bone down to the upward bend of the sinus to the bulb is all that we should do. It is important to remove bone as far back as the origin of the superior petrosal sinus, as a mural clot in this situation is sometimes missed.

TREATMENT

The treatment of septic thrombosis is surgical. It is sometimes said that thrombosis is a natural protective mechanism and that we should not interfere. This is true ; but once the thrombus is infected the protective mechanism has failed. Before Ballance and Lane opened the sinus. patients with septic sinus thrombosis were all left to nature, and nearly all of them died.

The infecting focus must be eliminated. To do this we must:

(1) Remove all infected bone.

(2) Isolate the infected area of the vessel from the circulation.

(3) Drain the infection.

OPERATION

Instruments. As for mastoid operation, with twelve additional hæmostats, a second set of dissecting instruments, and an aneurysm needle for ligation of the internal jugular vein if this proves necessary.

Anæsthetic and *position* of the patient are the same as for the mastoid operation.

First stage. Perform the appropriate mastoid operation. In acute mastoiditis with sinus thrombosis it is hardly ever advisable to perform a radical mastoid operation. It is very rarely necessary even to remove the posterior wall of the bony meatus. The rule is free removal of all infected bone.

Second stage. Make a horizontal incision 2 inches long backwards from the centre of the mastoid incision. The incision should go down to the bone. Secure spouting vessels, turn back the flaps, and pick up the edges of the pericranium with the pressure forceps. Then expose the sinus in the mastoid wound. This is best done with a broad gouge, and at the bend of the sinus. When a part of the wall is exposed, greased ribbon gauze can be pushed into the bony breach to separate the sinus from the bone, and the exposure is then completed with round-ended bone-cutting forceps. The sinus must be freely exposed, backwards until normal wall is found, and forwards for the whole length of the descending part.

Third stage. A full ½-inch of normal wall is exposed posteriorly. The dura is then carefully separated from the bone so that a pack can be quickly inserted if need be. The sinus is then slit open over the whole length of infected wall. The free gush of blood from the posterior end clears out the loose clot. The vessel is now obliterated behind by packing greased ribbon gauze *between* the bone and the sinus wall, *not* into the lumen of the sinus. If this does not control the

bleeding entirely, a plug of muscle is cut from the sterno-mastoid and packed into the sinus. This method, which was first used by Sydney Scott, is an adaptation of the muscle graft for the sinus wall, and is equally efficacious. If the bleeding is uncomfortably profuse, it can be diminished by raising the patient's head. It is questionable whether the clot should be curetted if it is adherent to the vessel wall. It is probably sufficient to secure free bleeding and widely open the infected area.

Fourth stage. The clot is followed forwards and downwards towards the bulb. If free bleeding is obtained, the lower end of the sinus is obliterated. If not, the clot is followed down as far as possible and the jugular vein is tied. Operations have been described for exposure of the jugular bulb, but it is doubtful if they are ever necessary. If the apex of the mastoid is removed and the posterior border of the sinus followed down to the bend, adequate access can usually be obtained.

Ligation of the Internal Jugular Vein

If in doubt, ligate; it may do good, it cannot do harm. Always ligate if there is not a free flow of blood from the lower end of the sinus; above all, if pus escapes from the lower end.

Remember:

(1) That the jugular vein may be collapsed and surrounded by inflamed lymph glands, so that the operation is not always easy.

(2) *To tie well below the thrombus, but for choice, above the common facial vein.* If compelled to tie below the common facial vein, isolate it and divide it, or infection may spread along it into the deep veins and so into the cavernous sinus.

(3) Not to tie the jugular vein without dealing with the infected sinus, or else the thrombosis will extend above the ligature into the torcular or the petrosal sinuses. Sometimes, in a desperate case, it is justifiable to tie the jugular vein in the hope that in the next twenty-four hours the patient's condition may improve enough for us to attack the sinus, but this is the only exception to the rule.

Operation. A protective dressing on the mastoid, clean gloves, clean towels, and *a set of dissecting instruments* which have been kept unsoiled during the operation on the sinus are required. This set includes retractors, blunt-ended Mayo scissors, and two aneurysm needles, which should have broad, well-rounded tips. An aneurysm needle with a rough or sharp tip, such as these instruments too often have, is dangerous enough in action against a tough-walled artery; it is inviting disaster to use such a weapon on a thin-walled vein. A large eye makes threading much simpler.

Position. A sand-bag under the shoulders, and the chin turned to the opposite side; but *do not* extend the head too far, and *do not* rotate it too much, or the sterno-mastoid will be stretched so tightly that retraction will be difficult.

The skin is prepared with picric acid in spirit or with flavine.

(1) An incision 4 inches long is made from the angle of the jaw downwards and along the anterior margin of the sterno-mastoid. It is a help to "slant" the incision a little forward, starting $\frac{1}{2}$-inch behind the anterior edge of the sterno-mastoid and finishing $\frac{1}{2}$-inch in front of it. The most common mistake is to start the incision too low down. Expose the platysma in the whole length of the wound, divide or pull aside the external jugular vein, and then incise the platysma. This is best effected by picking it up with two pairs of toothed dissecting forceps, one held by the operator and the other by his assistant, and then by incising and slitting with blunt-ended scissors.

(2) Expose and define the anterior edge of the sterno-mastoid. Remove any inflamed lymphatic glands. *Tie off bleeding points;* do not leave pressure forceps on to obstruct the field. Draw the sterno-mastoid outwards and backwards, and then identify the carotid sheath. If in doubt, look for the pulsation of the carotids. In cases of difficulty there is a temptation to rummage in the neck and call it "blunt dissection." This makes identification much more difficult.

(3) Pick up a loose piece of the carotid sheath with toothed forceps, as before, and open it. The vein lies on the outer side, and is usually further back than we expect. Trace the vein up to the parotid and down to the end of the incision. Identify the common facial vein and define the limit of the thrombus. The thrombosed region does not show any change during respiration, and the vein below it is collapsed as far as the next main branch. The presence of thrombus is confirmed by very gentle palpation.

(4) Follow the vein until clear of thrombus, and then pass the aneurysm needle from within (i.e. from the carotids) outwards, hugging the vessel closely to avoid damage to the vagus, which lies behind and internal to it. Tie double ligatures a good $\frac{1}{2}$-inch apart, draw the vein up, and divide between ligatures. Let the cardiac end fall back into the wound.

(5) Follow the cephalic end up as far as possible, tying and dividing every tributary. Bring the cephalic end to the surface, stitch it to the skin, open it, and clear out as much clot as possible by gentle curettage.

(6) Close the skin wound below with sutures, put in a rubber dam drain, and cover with a large dressing.

After-Treatment. The mastoid wound is left widely open and loosely

packed with well-greased gauze. The outer dressing should be changed the day after operation. The wound packing may be well soaked with flavine in oil, and if progress is satisfactory, it may be left *in situ* for several days. The gauze plugs obliterating the sinus should not be removed until the eighth day. It is well to remove them under an anæsthetic, so that fresh plugs can be inserted at once if there is any recurrence of hæmorrhage. The great advantage of Scott's method of plugging the sinus with a piece of muscle is that we avoid this danger.

If at the time of operation there are no metastatic abscesses in the lung, and no intra-cranial complications such as meningitis or cerebellar abscess, the patient should recover. Unless operation has been so long delayed that he is already moribund, he is not likely to succumb to septicæmia after the operation. As a rule, the signs of septicæmia quickly pass once the source of infection has been removed. *Blood-transfusion* is valuable when there is definite anæmia, but it should only be undertaken by an expert; haphazard transfusion can do more harm than good. *Serum treatment* is sometimes useful when the blood culture is positive.

OTOGENOUS MENINGITIS

In this section, meningitis means pyogenic inflammation of the piarachnoid (lepto-meningitis). It is essential to remember that "meningeal irritation," and "serous" and "suppurative" meningitis, are stages in a continuous process, a pyogenic inflammation, as modified *by the virulence of the infecting organism and by the local and general* resistance brought into action against it (see also page 5484.)

Organisms invade the meninges either:

(1) Directly through infected tissue, e.g. by extension of an extra-dural abscess.

(2) *By anatomical channels of communication, such as the piarachnoid sheath of the eighth nerve, as in suppurative labyrinthitis.*

(3) By septic thrombosis of the cerebral veins. For the greater part of their course these veins have no *tunica adventitia*; they are *endothelial tubes in the piarachnoid mesh. Where these tubes are in* close contact with infected bone or with infected sinus wall, they are particularly vulnerable. The vessels of the petrous apex, which perforate the dura and often communicate with the veins of the tympanic plexus, are a common route of infection.

(4) By rupture of a cerebral abscess into a ventricle, or of a cerebellar abscess into the cisterns; by direct invasion from a suppurating middle ear by a congenital defect of the temporal bone, or through the line of an old fracture; or by invasion by the blood stream. These are all rare.

Diagnosis. The cardinal signs are headache, fever, and stiffness of the neck. Early irritation suggests cortical spread; early coma, basal. Sudden coma or delirium with high fever and paralyses usually means that a cerebral abscess has burst into a ventricle.

Papillœdema is found in the majority of cases. Signs of meningitis with nystagmus and an inactive labyrinth point to invasion through the internal auditory meatus along the sheath of the eighth nerve.

Lumbar puncture is a valuable aid to diagnosis, but not more than 5 cc. of fluid should be taken. There is no doubt that sudden death has followed withdrawal of a large quantity of cerebro-spinal fluid in patients with intra-cranial complications. The cause is obscure, but the fact is undoubted. (This prohibition does not apply once the raised intra-cranial pressure has been relieved.)

The normal cell content is up to four cells per cubic millimetre. If cells exceed this figure, or if polymorphs are present, the fluid is abnormal. The most important chemical tests are the estimation of chlorides and of glucose. It will be seen from the table that the falls of chlorides and of glucose are important diagnostic signs.

CHEMICAL COMPOSITION OF THE CEREBRO-SPINAL FLUID (GREENFIELD)

(Figures in milligrammes per 100 cc. of fluid.)

	Blood plasma.	Normal C. S. F.	*Meningitis.*
Chlorides	560–620	725–750	600–680
Glucose	100	55–65	0–30
Urea	10–30	10–30	10–30
Calcium (diffusible)	6–7	6–7	6–7
Magnesium	2·2–3	3–3·5	2–3
P, as inorganic phosphates	2–5 5	1·5–2	2–3
Sulphates	4	1	1
Uric acid	3	0 3–1·3	1·1–4·8

As infection advances, the protein content rises.

Bacteriological examination is principally of importance for the prognosis; we must not wait for the appearance of organisms in the fluid.

TREATMENT

Otogenous meningitis is a surgical condition and must be treated surgically.

Patients who die of meningitis are not killed by increased intra-cranial pressure but by septic poisoning. Therefore, the primary focus must be eliminated and adequate drainage provided.

Elimination of the primary focus means the removal, as far as it is anatomically possible, of every particle of infected bone. It does not mean performing a mastoid operation, exposing a patch of dura, and hoping for the best.

Drainage

Normally, the cerebro-spinal fluid is secreted by the choroid plexuses, reaches the surface by the intercellular channels and the perivascular piarachnoid sheaths, and passes into the blood stream of the venous sinuses via the arachnoid villi.

In inflammatory conditions, especially when the protein content of the fluid rises, the absorption by the villi is hindered and, as the pressure rises, the fluid can pass backwards along the perivascular sheaths. Thus the whole brain is percolated with infected fluid. and drainage, to be adequate, must therefore ensure that the fluid from the choroid plexuses continuously washes out the brain from within. It should be noted that:

(1) Incision of the meninges is useless, except for the release of a localised collection of fluid. The brain bulges into the incision and blocks it.

(2) Attempts at drainage by lumbar puncture or by puncture of a cistern are only temporary expedients. The meninges collapse on the central axis and the flow from the perivascular spaces is hindered. (An exception to this rule is drainage of the cisterna pontis in meningitis of labyrinthine origin.)

(3) The vigorous resistance of the meninges to infection is a difficulty. Adhesions form, and pockets of infected fluid are isolated.

Many attempts have been made to overcome these difficulties. Jenkins devised a method of *transthecal irrigation* which gave some brilliant results; unfortunately, this method depends on such exactitude of minutiæ that it is not suitable for general use. The most reasonable and generally applicable method is *Kubie's forced drainage.*

Ten years ago Weed showed that the secretion of cerebro-spinal fluid was affected by changes in the osmotic tension of the blood. On this observation Kubie has based his method of treatment. The principles may be stated as follows:

(*a*) Normally, nearly all the fluid is formed by the choroid plexus; some is formed by the cerebral capillaries, but this is quickly re-absorbed and does not reach the subarachnoid space.

(*b*) When pressure is reduced by drainage, re-absorption is reduced, and the fluid from the capillaries passes by the perivascular track to the subarachnoid space.

(*c*) The rate of formation can be enormously increased by lowering

the osmotic tension of the blood and simultaneously draining the subarachnoid space; this does not increase the intra-cranial pressure or cause cerebral œdema.

(*d*) In inflammatory conditions the products of inflammation are carried along with the fluid.

(*e*) It is probable, but not proved, that forced drainage carries immune bodies into the cerebro-spinal fluid through the normal barrier.

(*f*) The best method of reducing the osmotic tension of the blood is by intravenous injections of hypotonic saline, with sufficient salt to prevent hæmolysis. "Forced drainage" differs from simple drainage in that it is really an *irrigation*; thus the meninges do not collapse on the central axis, which obstructs the escape of cerebro-spinal fluid, the subarachnoid space is kept full, and the perivascular drainage is increased.

The method is not suitable for cases of meningitis secondary to abscess until the abscess has been drained, nor for patients with pulmonary, cardiac or renal disease. Kubie regards bacteriæmia as a contra-indication, but considering the free passage of cerebro-spinal fluid into the circulation we may regard all cases of septic meningitis as potential cases of bacteriæmia, so that this objection is not valid. The method suggested is to drain off the cerebro-spinal fluid by lumbar puncture and to give intravenously 2 to 3 litres of 0·45 hypotonic saline in the course of one to three hours. Drainage can be repeated daily, or even continued steadily for a whole day.

Procedure in a case of Meningitis

Meningitis is a surgical emergency. When the diagnosis is established, the theatre must be prepared. The method of attack depends on the immediate cause.

(1) *There is suppurative labyrinthitis with meningitis.* The indication is clear. We open the labyrinth and drain the meninges, in this case the cisterna pontis, along the line of invasion which is the internal auditory meatus. This is the "trans-labyrinthine drainage" of West and Scott. In meningitis of labyrinthine origin it is the only satisfactory method. It is as futile to use it for meningitis arising elsewhere than in the labyrinth as it would be to remove the appendix for peritonitis caused by a perforated gastric ulcer.

Anatomical points. The internal auditory meatus is 8 to 10 mm. long and 4 to 5 mm. in diameter. It is directed slightly obliquely backwards and inwards, making an angle of 45 degrees with the long axis of the petrous pyramid. The base of the cochlea corresponds with

the anterior half of the outer end; the carotid is below and in front (Ballance). In the meatus the facial nerve lies above the auditory. The arachnoid sheath is attached to the walls as an open funnel.

Operation. Instruments and anæsthetic as for vestibulotomy.

Stages 1 *and* 2. Radical mastoid operation and vestibulotomy—superior and inferior.

Stage 3. The labyrinth is washed out with iodine, and the surgeon using fresh gloves and clean instruments, then perforates the inner vestibular wall. This is best done by taking the "bimeatal transcephalic line" (Scott) and placing a small chisel against the inner wall, aiming at the opposite meatus. A very light, resolute tap of the mallet is far safer than trying to push the chisel through. The opening is cautiously enlarged, and the cavity at once fills with cerebro-spinal fluid. A few strands of silkworm-gut are twisted to make a drain, and are slipped into the internal auditory meatus. The post-aural wound is stitched up. No packing is put in the ear.

(2) *There is an abscess, cerebral or cerebellar, or lateral sinus thrombosis.* Here the operation deals with the focus.

(3) *There is no known cause apart from the mastoid infection.* Here the best method is that described (with slight variations) by Eagleton, Neumann and Voss.

Operation. Half the head is shaved. *Instruments* are as for the radical mastoid operation, with twelve additional hæmostats.

(1) *Open the mastoid antrum and remove the outer attic wall.* It is not advisable to perform a radical operation unless the condition of the middle ear demands it.

(2) Expose the bend of the lateral sinus and remove the bone posterior to the sinus in order to expose a large area of cerebellum.

(3) Remove the *tegmen tympani et antri* and a large area of the squamous temporal.

(4) Shave down the zygoma to the capsule of the temporo-mandibular joint.

(5) Carefully strip the dura off the superior and posterior surfaces of the petrous bone.

(6) Gouge away the "solid angle" of the petrous bone until the superior petrosal sinus is freed from its groove. If possible, respect the superior vertical canal.

The whole upper surface of the petrous can now be examined, any abscess drained, and infected bone cut away. Stripping of the dura is made much easier by an occipito-atloid puncture.

After-Treatment

Whichever method is adopted, Kubie's forced drainage should be started immediately. The intravenous injection is begun by an assistant while the operation is in progress.

The loss of fluid is so great that vigorous steps must be taken to replace it. Sleep should be ensured by the administration of paraldehyde. Morphia is avoided if possible, as it diminishes the activity of the choroids. Intrathecal injection of chemicals seems useless and may even be dangerous. Intrathecal injection of sera has the disadvantage of increasing the protein content of the fluid. The outer dressing should be changed whenever it is soaked, but otherwise the patient must be disturbed as little as possible.

INTRA-CRANIAL ABSCESS. (See also Vol. II, page 1827.)

A. *Extra-dural and Subdural Abscesses.*

Extra-dural abscess is the most common and least dangerous of all intra-cranial complications. It is seldom diagnosed before operation, and is usually discovered in the routine exploration of carious tracts in the bone. When found, the abscess is drained by the free removal of all overlying bone. On no account must the operator scrape, curette, or otherwise interfere with the granulating surface of the underlying dura unless there is evidence of a deeper brain abscess. The commonest sites for an extra-dural abscess are: (1) Over the lateral sinus (2) forward in the zygomatic region; and (3) on the superior surface of the petrous bone.

Subdural abscess is rare, except as an intermediate stage in the development of brain abscess. When present, it usually lies above the tegmen.

B. *Brain Abscess* is either cerebral or cerebellar. The pathology and the problems of treatment are the same in both.

Pathology. The abscess usually starts in the avascular area of white matter between the areas supplied by the basal and cortical vessels. Infection travels by the perivascular sheath; less frequently by retrograde thrombosis of veins; occasionally by endarteritis and embolism.

First, there is local encephalitis, which is diffuse and sometimes hæmorrhagic, with central destruction and migration of leucocytes. If there is good resistance, the destruction is localised, an abscess wall forms, and the abscess is enscapsulated, with a definite formation of fibrous tissue in the wall. It is probable that, in favourable cases, a wall begins to form at the end of the first week, and a firm capsule is present between the fourth and sixth weeks.

The time of operation—early or late?

On this point there is still considerable disagreement. Some surgeons advise us to operate as soon as we diagnose an abscess; others say we should wait until the abscess is encapsulated. On the whole, it seems better to wait. In the acute stage, drainage is practically impossible, as there is no defined cavity, and operation has all the disadvantages of disturbing an acutely inflamed region. Also, it has been shown by Borries that hæmorrhagic encephalitis may give all the signs of abscess and yet subside without operation. If intra-cranial pressure rises to a dangerous degree, or if there is real danger to vision, a decompression operation in a healthy area is justifiable and preferable to premature intervention in the area of inflammation.

These remarks indicate no more than the general trend of opinion. It is too early as yet to lay down hard and fast rules, and the evidence of statistics is indecisive. It is undeniable that the surgeon who waits for encapsulation gets far better operative results: but it is only fair to admit that in the worst cases the patient may die before the capsule has had time to form, and it is possible that some of these patients might be saved by early operation.

How can we judge the progress of encapsulation? The period of time which elapses after the first signs of intra-cranial invasion is a rough guide. The absence of febrile symptoms is not reliable, as they are rarely pronounced, even in the early stage. The presence and nature of neurological symptoms is not of much help, as these may be due to irritation around an encapsuled abscess or, especially in cerebellar cases, may disappear before encapsulisation is complete. *The most reliable evidence is the condition of the cerebro-spinal fluid.* Usually the fluid is at first turbid but sterile, with many cells. As the abscess is shut off by its wall, the fluid clears and the cells diminish, until we have a clear sterile fluid with scanty cells. A clearing fluid with increasing intra-cranial signs establishes the diagnosis of an abscess. If the fluid contains many cells and increasing organisms, it is proof that the isolation of the abscess has failed.

DIAGNOSIS OF INTRA-CRANIAL ABSCESS

Satisfactory diagnosis depends on the observation and correct interpretation of small, and often transient, signs. The *signs and symptoms* of brain abscess may be roughly grouped as follows:

(1) Those due to sepsis: pyrexia, malaise, and increase in the leucocytes in the blood and cerebro-spinal fluid.

(2) Those due to increased intra-cranial pressure: headache,

vomiting, papillœdema, slowing of the pulse, rise of blood-pressure, rise of pressure of the cerebro-spinal fluid, fits, coma and respiratory paralysis.

(3) Those due to destruction or irritation of the cortex or subcortical tracts. These are the "localising signs" and are discussed later.

In practice these factors modify each other in various ways, but some general rules can be laid down:

(1) Headache is the most constant symptom. No patient should have a persistent headache after a successful mastoid operation. There must be some cause, and that cause must be found.

(2) Papillœdema is frequent, but not constant. It is more common *in cerebellar than in cerebral abscess.*

	Otitic abscess	Otitic hydrocephalus.
Age . . .	Any age.	Almost always children and adolescents.
General condition	The patient complains of malaise and appears ill.	Between the attacks of headache the patient feels and looks well.
Fundi . . .	Often normal; if papillœdema is present it is of slight degree.	Papillœdema constant: usually measurable swelling with hæmorrhages and exudate.
Localising signs .	A right-sided temporal lobe abscess may be relatively silent; a cerebellar or left temporal abscess usually gives rise to characteristic localising signs.	No localising signs are present. A sixth-nerve paralysis on the side of the lesion is present in a fair number of cases. Rarely, unilateral or bilateral convulsive seizures may occur, or the plantar response on one or both sides may be extensor—the result presumably of increased intra-cranial pressure.
Cerebro-spinal fluid	Clear, pressure moderately increased, protein content constantly above normal, cells nearly always increased (mainly lymphocytes with an occasional polymorph.)	Clear, pressure often above 300 mm., quantity abundant, no excess of protein or of cells.

(3) Vomiting is not constant. The "typical" projectile vomiting without nausea is uncommon.

(4) Pyrexia is slight, and is often unnoticed unless a two-hourly chart is kept. An occasional slight "shivering fit," not worthy of the name of rigor, is not uncommon.

(5) Slowing of the pulse is usually present to some degree. It is a little too slow for the temperature. In the late stages it is marked.

(6) Malaise, constipation, and drowsiness or irritability are usual.

Stereoscopic skiagrams are sometimes helpful, if they provide positive evidence.

Lumbar puncture has already been considered and, as previously stated, not more than 5 cc. should be withdrawn at a time.

Ventricular puncture (see Vol. II, page 1778,) is sometimes of great help. Dilatation of one ventricle suggests an abscess on the *opposite* side. Dilatation of both ventricles suggests an abscess of the cerebellum with obstruction to the passage of cerebro-spinal fluid below the tentorium.

Differential Diagnosis

Encephalitis lethargica is distinguished by the unchanged chloride content of the cerebro-spinal fluid and by the lymphocyte pleocytosis.

Symonds has described a condition of "*otitic hydrocephalus*" which may cause confusion.

The only treatment needed for this condition is extirpation of the dural infection and lumbar or ventricular puncture.

DISTINGUISHING FEATURES OF CEREBRAL AND CEREBELLAR ABSCESSES

Cerebral abscess of otitic origin nearly always starts in the temporo-sphenoidal lobe, but *occasionally in the parietal or frontal*. It occurs in about 6 per cent of all cases of intra-cranial complications of middle ear disease. It is nearly twice as common as cerebellar abscess; is most common in the second and third decades; is twice as common in men as in women; is four times more common in chronic than in acute cases; and is equally common on the right and left sides.

Signs peculiar to cerebral abscess. In right-handed persons the left temporal lobe is particularly concerned with speech. A curious disturbance described by Sydney Scott as "word amnesia" is of the utmost significance. Although the patient shows no obvious signs of aphasia, there is "an inability to correlate ideas of objects with names of objects." When the patient is shown a number of common articles—coins, matches, keys, a pencil, and so on—he will answer correctly for a time, then suddenly repeat a word and fail to describe some particular

object. When told what it is, he may still be unable to describe how to use it. *Loss of a homonymous sector of the visual fields*, usually an "indentation" but occasionally complete hemianopia, is the most common sign. *Contralateral irritation or hemiplegia* is a late sign and of grave prognostic significance, but it does not prove that the abscess has spread into the pyramidal tract. It usually means that the tract has been affected by the advancing œdema around the abscess. *Paralysis of the third and sixth nerves* is a sign of increased pressure, rather than a specific sign of temporal lobe abscess.

Cerebellar abscess is only one half as common as cerebral abscess. It is equally common on the two sides, twice as common in men as in women, and is most common in the second and third decades of life. There is no evidence that children in the first decade are particularly susceptible.

There are three ways in which aural suppuration can cause cerebellar abscess:

(1) By spread of infection from labyrinthitis; usually through necrosis of the labyrinth wall and the formation of an extra-dural abscess.

(2) By spread of infection from a thrombosed lateral sinus.

(3) By osteitis and direct spread; usually through the posterior antral wall and the bone deep to it (Trautmann's triangle); and less frequently through cells postero-inferior to the lateral sinus.

It is said that the labyrinthine route is the most common, but probably there is little difference between the three.

Signs peculiar to cerebellar abscess.

The *signs of increased intra-cranial pressure* are usually earlier and more severe than in cerebral abscess. Retraction of the head, stiffness of the neck and Kernig's sign are all indications of increased pressure, not true cerebellar signs. This is because: (1) the rise of pressure is primarily subtentorial, so that pressure on the brain stem is more marked; and (2) the compression and distortion of the brain stem obstructs the aqueduct of Sylvius and produces internal hydrocephalus above the tentorium. *Signs of septic absorption* may be masked by causal sinus thrombosis. Extreme wasting is sometimes seen. *Signs due to irritation or destruction of the cerebellar tissue* are often transient, and some are difficult to distinguish from those of labyrinthine irritation and destruction.

Peculiar to cerebellar lesions, whatever may be the condition of the labyrinth, are signs due to disturbance of muscle tone and co-ordination. They are:

(1) *Hypermetria.* When attempting to touch anything, the hand on the affected side overshoots the mark. If the patient tries to write, the dots are not over the "i's," and the commas are wrongly placed. If with the eyes closed and arms extended he tries to make the forefingers meet, he misses and the hands cross. If told to touch first his knee, then the examiner's forefinger, and finally his own nose, he finishes up on his cheek or jaw.

(2) *Hypotonia.* If the examiner throws up the patient's relaxed arms, that on the affected side drops limply.

(3) *Dysdiadokokinæsia* is shown when the patient is told to pronate and supinate both wrists as quickly as he can. The hand on the affected side soon begins to waver and make movements out of time with the other hand.

Cerebellar catalepsy and convulsions are rare. The *cerebellar position*, lying on one side in a semi-flexed attitude, often with the head tucked over to the side of the lesion, and *the lateral deviation of the eyes*, usually to the healthy side, must be regarded as "forced positions," not as pressure effects.

Signs common to cerebellar abscess and labyrinthitis.

Nystagmus, vertigo, pointing errors, and falling occur in most cases of cerebellar abscess, and in all cases of suppurative labyrinthitis. It would be dangerous as well as inaccurate to express a rigid opinion on these points, but we may say that there are some broad distinctions between these signs as produced by the two conditions:

(1) In labyrinthitis, vertigo is more noticeable than motor abnormalities of equilibrium. In cerebellar abscess, the opposite is true. Also reeling and staggering (Romberg's sign) are more marked, and last longer in cerebellar cases.

(2) In labyrinthitis, the irritative stage is very short; in cerebellar abscess, the irritative signs are more noticeable than the compensatory.

(3) In labyrinthitis, the signs follow a course of orderly violence, progressing rapidly until destruction is complete, remaining for a time at a maximum and then gradually diminishing. In cerebellar abscess, the signs increase as the disease advances, but they increase unevenly with remissions and exacerbations.

When labyrinthitis produces a cerebellar abscess, destruction of the labyrinth precedes abscess formation. In the cases where labyrinth destruction and posterior fossa infection advance *pari passu*, meningitis, not abscess, is the result.

The principal points of difference between the two conditions are summarised in the following table:

DIFFERENTIAL DIAGNOSIS BETWEEN LABYRINTHITIS AND CEREBELLAR ABSCESS

	Points to be considered.	Cerebellar abscess.	Labyrinthitis.
(a)	Spontaneous nystagmus .	Coarse.	Fine.
	1. Direction . .	Horizontal, vertical, *rotatory, diagonal.*	Nearly always horizontal, *rotatory.*
	2. Quick or slow components	Not easily distinguishable.	Easily distinguished.
	3. Relation to falling and past-pointing	Independent	Always in opposite direction.
	4 Destruction of labyrinth	Increases nystagmus.	Nystagmus gradually passes off.
	5. Remarks . .	Remains at a maximum or increases.	In labyrinthitis serosa, change of position of the head alters position of nystagmus.
(b)	Past-pointing .	Unilateral, on affected side.	Bilateral.
		Independent of nystagmus.	Always opposed to nystagmus.
		If present without nystagmus, a proof of cerebellar lesion.	Never present without nystagmus.
		Lasting.	Quickly disappears when the labyrinth is destroyed. Not always evident in labyrinthine irritation.
(c)	Falling	Independent of the position of the head and the direction of nystagmus.	Depends on the position of the head and nystagmus (opposite to the direction of nystagmus).
		Permanent.	Soon disappears after destruction of the labyrinth.
(d)	Deviation of gait .	Independent of the nystagmus.	Always opposed to the nystagmus.
(e)	Turning to the side .	Difficulty in turning towards the affected side.	Turning to either side usually easy.

TREATMENT

The treatment of brain abscess is operative, and no case of brain abscess is inoperable until the patient is dead. Operations for brain abscess have been carried out with the patient under artificial respiration throughout the operation, and the patient has recovered.

The decision as to the best time to operate is discussed on page 4679. The *method* must suit the individual case, but we can accept some general principles :

(1) It is generally agreed that the causal focus of sepsis in the ear must be extirpated. This does not mean that a radical operation is always necessary. The extent of operation on the ear should be suited to the extent of sepsis and destruction of the ear.

(2) *At this stage of operation the dura of the suspected region* should be freely exposed.

(3) When there is an abscess of old standing (months or years) with a sinus, it is probable that the capsule will be dense and tough, that the abscess will be loculated, and that no ordinary drainage operation will suffice. The abscess may be emptied, but the capsule remains and fills up again. In such a case, the abscess should be treated as a tumour, and dissected out through a separate opening over an uninfected area of the brain.

(4) When a recent area of pachymeningitis or of adhesion between dura and piarachnoid is found in the region exposed by extension of the mastoid wound, it may be taken for granted that infection has passed through that area, and it is through that area that the abscess should be sought.

(5) If no such area is found, the brain should be explored through a separate opening made with the drill in a clear area. This especially applies to the cerebrum. In the cerebellum it is probably better to enlarge the original bone breach. Exploration should be carried out with a graduated brain-exploring needle. Sharp-pointed instruments should be avoided. Exploration with the finger-tip should be left for the very few who can do it safely ; most of us cannot.

(6) For superficial abscess use free exposure, free incision, and open drainage ; for deep abscess, closed drainage. The method is that suggested by Cairns, whereby a small incision is made in the dura, and a Jacques No. 10 catheter is pushed in to the depth marked on the exploring needle. A variant of this method had been practised by *Lemaitre. He starts with a tube the size of a No. 1 catheter, and* every other day passes in one a size larger. The disadvantage of this method is that it entails frequent disturbance of the region.

(7) Dressings should be as few as possible, and the tube should not be disturbed. Post-operative œdema of the brain is common, but it is generally agreed that we should refrain from further operation. Lumbar puncture is helpful and justifiable.

Some Special Points

(1) Osteoplastic flaps are not very successful in the treatment of brain abscess.

(2) In cerebellar abscess the most common track of invasion is internal to the lateral sinus. If there is real difficulty in obtaining adequate drainage here, it is quite justifiable to obliterate the lateral sinus, preferably by plugging it with muscle above and below, and carrying the incision through it. Where the sinus is already thrombosed this should always be done.

(3) The Doyen perforator and burr is a safer and more serviceable instrument than the trephine.

(4) Immobilising the dressing and drainage-tube by starch bandages (Cairns) has proved valuable.

(5) Hernia cerebri is a reaction against infection. The less we damage the brain, the less we risk secondary infection by meddlesome dressings and "hunting for pockets", and the smaller our dural incision in deep abscess the smaller is our risk of hernia cerebri.

THE OPERATIVE TREATMENT OF FACIAL PARALYSIS

(see also page 3745)

Until a few years ago facial paralysis, whether caused by Bell's palsy, suppuration, or injury at operation, could be treated only by transplanting operations. In these operations the peripheral end of the facial nerve was united to one of the available cranial nerves. The nerves chosen were the spinal accessory, the hypoglossal, the glosso-pharyngeal and the descendens noni. The anastomoses were never entirely satisfactory. If the spinal accessory or the hypoglossal was used, there was some paralysis of the region supplied by the "trunk" nerve, such as dropped shoulder or wasting of the tongue, and associated movements from the innervation field of the "trunk" nerve, which were always unsightly and often distressing; for example, in a case where a successful facio-hypoglossal anastomosis had been made, every movement of swallowing caused "a ripple of muscular contraction which spread over the face" (Ballance). Also, all expressions of emotion, the "automatic-associated" actions of the facial nerve itself, are irregular and exaggerated. If the glosso-pharyngeal nerve is used for the anastomosis, there are no associated movements from the trunk nerve, the symmetry of the face when at rest is restored, and some isolated movements are recovered, but there is no return of the movements of emotional expression.

During the last four years, Ballance and Duel have shown that it is possible to repair the facial nerve in the Fallopian canal by grafting and suturing when the nerve is divided, or, if the nerve is not divided, as in Bell's palsy, to restore function by decompression. In many operation injuries, decompression is the only thing needed, as the nerve is not actually divided, but only compressed by a fracture of the wall of the canal.

The method is as follows:

(1) A radical mastoid operation is performed, with free removal of the bony wall and floor of the meatus.

(2) The dissection is carried down into the neck, and the nerve is identified at the stylo-mastoid foramen.

(3) The facial canal is opened from the foramen to the bend between the oval window and the prominent bulge of the external semicircular canal.

(4) The sheath of the nerve is freed at the stylo-mastoid foramen and slit up for the length of the exposure. In cases of Bell's palsy and in operative injuries where the damage is slight, nothing more need be done.

(5) If the nerve is severely damaged, the injured part is excised by two clean cuts of a cataract knife, and the graft is laid in the canal and secured by a thread stitch.

(6) The graft is then covered by a layer of gold leaf or platinum foil.

The graft. The nerve now chosen is the external cutaneous nerve of the thigh. It seems best to divide the nerve and allow it to undergo complete Wallerian degeneration before using it as a graft. This means an interval of three weeks. A graft from another subject (heteroplastic graft) can be used successfully if the donor and the patient are of the same blood group.

An important point is that the gap to be sutured is usually much larger than would be expected; the average length of the graft needed in operative repair is about 20 mm. It is important that the graft, once inserted, should be as little disturbed as possible.

Indications. This operation should replace anastomosis with peripheral nerves except in those cases where the central end of the nerve cannot be reached, such as fractures of the petrous bone or tuberculous osteitis. Sepsis is not a contra-indication. Duel believes that where facial paralysis follows operative accidents or suppuration, exposure and grafting should be done without delay. In cases of Bell's palsy, a period of several months without improvement is a justifiable indication. If a successful graft is made, the possibility of curing the paralysis

seems to depend not on the length of time which has elapsed since the injury, or on the length of the gap which must be bridged, but on the condition of the muscles. In one case of twenty years' standing with advanced muscular atrophy there was still a slight response to the galvanic current, and a grafting operation improved the patient's condition so far that he could shut the eye, and sleep with the eye shut. If there is no response to the galvanic current, it is probably useless to attempt to restore function by a graft.

ACKNOWLEDGMENT

I would like to express my great indebtedness to Messrs. H. K. Lewis and Co. for the loan of many blocks and illustrations from Watkyn-Thomas and Yates's *Principles and Practice of Laryngology*.—Editor.

PART XXVI

NOSE

by

P. J. Jory

Nasal Snares

Of the multitudinous varieties obtainable the Glegg snare is, in the opinion of the writer, easily the best (see fig 2536). The chief of its many advantages are:

(1) The ease and rapidity with which it can be threaded with wire.

(2) The adjustability of the size of the loop *after* the wire has been inserted.

(3) The rounded "stop" at the distal end which prevents the wire loop from being drawn into the barrel of the snare.

(4) The excellent visibility obtainable owing to the fact that the fingers are kept well out of the line of vision.

Antral Instruments

The antral trocar and cannula may be straight or curved according to the predilection of the operator Of the straight variety the Lichwitz (or some modification thereof) is the best known model; in Wharry's instrument a small raised

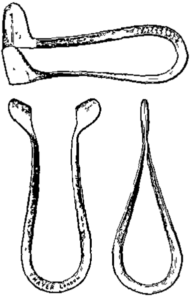


Fig 2529.—"Chiron" pattern of Thudichum's nasal speculum The set of the spring causes the end of the blades to throw outwards as the speculum closes. The right hand figure shows the blades approximated for introduction, and the left hand figure the position they take when opened out.

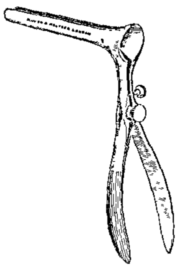


Fig. 2530.—Killian's nasal speculum.

ring placed half an inch from the distal end of the cannula prevents the possibility of penetration of the orbital floor duri[illegible] uncture of the antrum. Of the [illegible] cannulae the Myles type is [illegible] always had [illegible] of su[illegible] fits

PART XXVI

NOSE

by

P. J. JORY

Chapter X
Neoplasms of the Naso-Pharynx

Chapter XI
Spreading Osteomyelitis of the Skull

NOSE

CHAPTER I

Armamentarium

It has been stated that every rhinologist of repute has devised an operation, whilst the others have contented themselves with inventing some special instrument. In consequence, the number of rhinological instruments is legion, a fact to which testimony is borne by the catalogues of instrument makers and the stagnant masses of tools which encumber the instrument cupboards of nearly all hospitals. In these circumstances the writer will here designate merely the essential instruments, but in the description of various operations mention will be made of such instruments as have been specially devised therefor.

Nasal Specula.

For ordinary nasal examination Thudichum's specula have long been favoured by rhinologists. Those of the old pattern have rather a tendency to slip out of the nostril when widely opened, but in the improved model made by Mayer and Phelps (see fig. 2529) this tendency is obviated by the set of the spring, which causes the blades to throw outwards as the speculum opens. Should it be desired to bring the outer wall or the deeper parts of the nose into view, a long-bladed bivalve speculum such as Killian's or Kramer's (see fig 2530) is most suitable; whilst in these days of the ubiquitous electric auriscope a familiar model is the screw-action speculum of Duplay.

In the operation for cautery of the nasal mucous membrane the use of a metal-bladed speculum has obvious disadvantages, and Watson-Williams has designed a speculum with one blade of ivory and the other of wire. The blades are interchangeable so that either side of the nasal cavity may be protected at will (see fig. 2531).

Nasal Dressing Forceps.

These are so numerous and well known as to require no special description.

Nasal Punch Forceps.

Such instruments abound in innumerable varieties. The essential ones are those of Luc, Grunwald (see fig. 2532), and Hartmann, whilst for cutting in a forward or backward direction either Ostrum's or Wagener's forceps (see figs. 2533 and 2534) are required. The Chiron universal forceps are so designed that all forms of punch blades for intra-nasal use can be adapted to the handle (see fig 2535).

Nasal Scissors.

Some form of angled scissors is necessary for work upon the turbinate bones, and serration of the blades will tend to prevent them from slipping when in use. In certain types the blades are also angled to the right or left in order to facilitate manipulation in one or other nasal cavity.

Nasal Snares.

Of the multitudinous varieties obtainable the Glegg snare is, in the opinion of the writer, easily *the best* (see fig. 2536). The chief of its many advantages are:

(1) The ease and rapidity with which it can be threaded with wire.

(2) The adjustability of the size of the loop *after* the wire has been inserted.

(3) *The rounded "stop" at the distal end which prevents the wire loop from* being drawn into the barrel of the snare.

(4) The excellent visibility obtainable owing to the fact that the fingers are kept well out of the line of vision.

Antral Instruments.

The antral trocar and cannula may be straight or curved according to the predilection of the operator. Of the straight variety the Lichwitz (or some modification thereof) is the best known model; in Wharry's instrument a small raised

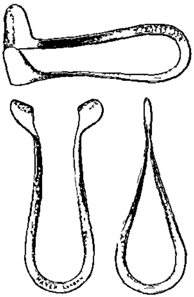


Fig 2529.—Gibbon's pattern of Thudichum's nasal speculum. The set of the spring causes the end of the blades to throw outwards as the speculum closes. The right hand figure shows the blades approximated for introduction, and the left hand figure the position they take when opened out

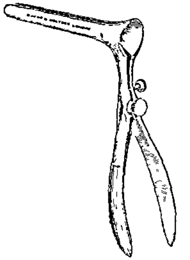


Fig. 2530.—Killian's nasal speculum.

ring placed half an inch from the distal end of the cannula prevents the possibility of penetration of the orbital floor during puncture of the antrum. Of the curved cannulæ the Myles type is the most popular. The writer has always had his cannulæ made of such calibre that an ordinary 10 cc. Record syringe fits snugly into the distal end, and has *found this to be a great convenience.*

For operations on the maxillary antrum many types of punch forceps have been devised; in addition to these the operator will require such instruments as Myles' retrograde chisel and trocar (see fig. 2537) or Tilley's harpoon and burr. The special

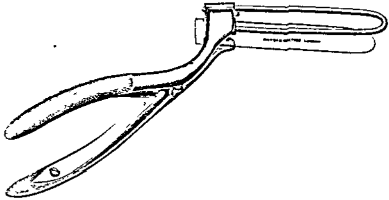


Fig. 2531.—Watson-Williams' cautery speculum. One blade is of ivory, acting as a cautery guard, the other of wire. They are interchangeable, so that either side may be protected.

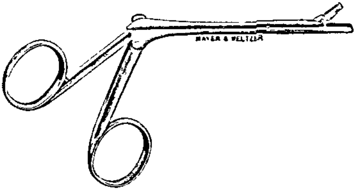


Fig. 2532.—Grunwald's nasal punch forceps. These have fenestrated blades, and may be made so as to cut straight forwards or in an upward or downward direction.

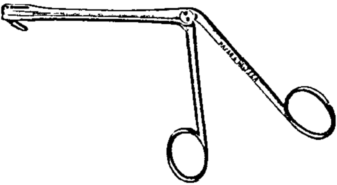


Fig 2533.—Ostrum's reverse-action antrum punch

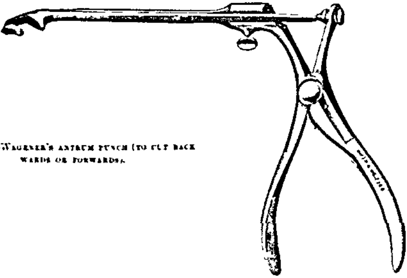


Fig 2534.—Wagener's antrum punch (to cut backwards or forwards).

instruments to be used for exploration of or operation on the ethmoids, sphenoidal sinuses and frontal sinuses, will be enumerated when the various operations are described; a similar procedure will be followed in the case of the operation of submucous resection of the nasal septum. It seems strange that, notwithstanding this galaxy of instruments specially designed for work in and about the nose, one

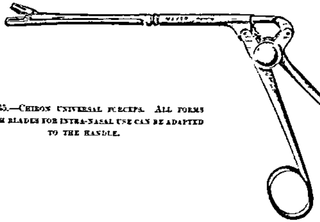


Fig 2535.—Chiron universal forceps. All forms of punch blades for intra-nasal use can be adapted to the handle.

sometimes makes use of some instrument which has a totally different primary purpose: for example an ordinary hernia director may be employed for the removal of a foreign body from the nose and a large aural speculum provides an excellent view of the cavity of the maxillary antrum during the performance of the Caldwell-Luc operation

Illumination

For the examination of the nasal cavities it is essential to employ some form of artificial light and for ordinary purposes an adjustable standard lamp is used, containing a frosted globe of 100 candle-power, in front of which a bull's-eye condenser

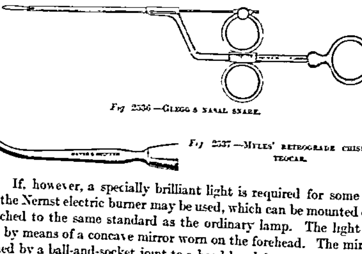


Fig 2536—Glegg's nasal snare.

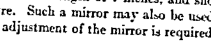


Fig 2537—Myles' retrograde chisel and trocar.

is fitted. If, however, a specially brilliant light is required for some particular purpose the Nernst electric burner may be used, which can be mounted on a cross-bar attached to the same standard as the ordinary lamp. The light is usually reflected by means of a concave mirror worn on the forehead. The mirror, which is attached by a ball-and-socket joint to a head-band (or spectacle frame), should have a focal length of 7 inches, and should contain a large oval aperture in its centre. Such a mirror may also be used for operating. If during the operation any adjustment of the mirror is required, asepsis can be maintained by the use of

an ordinary "clip" clothes-peg which has been sterilised by boiling, and then attached to the edge of the mirror.

At the present day electric headlamps of one form or another are widely employed for purposes of both examination and operation; these may be of the Clar type, in which the light from an incorporated electric lamp is reflected from a head mirror, or of the ordinary variety such as the Jenkins forehead lamp. The Cameron lamp is an excellent model, as it can be worn with comfort for a long period, and provides most efficient illumination. Such lamps may be worked from a dry cell, an accumulator, or (by means of a suitable resistance) from the ordinary house current. If one makes use of this type of illumination it is wise to carry spare bulbs and cells, as the latter have an annoying habit of running down at critical moments.

Anæsthesia.

Local anæsthesia is entirely adequate for all minor operations in the nose, whilst American and Continental rhinologists use it as the method of choice for even the major measures. In this country many operators employ general anæsthesia after a preliminary packing of the nose with cocaine and adrenalin or some similar agent, but our tendency is undoubtedly towards the greater use of local anæsthesia alone. A committee appointed some years ago in America under the chairmanship of Emil Mayer found that with local anæsthesia there was less hæmorrhage, far greater safety when operating in the vicinity of the cribriform plate, and that the danger of toxicity due to the local anæsthetic compared favourably with the dangers resultant from the administration of general anæsthesia. It is, however, true that the modern intra-tracheal methods of inducing general anæsthesia have removed many of these dangers, and have greatly simplified the performance of intra-nasal operations; the naso-pharynx and pharynx can be securely plugged with gauze to prevent blood or infected secretions reaching the trachea or œsophagus, whilst the operator is no longer hampered by the presence of the anæsthetist's paraphernalia. The use of such anæsthetics as avertin, nembutal, evipan and pentothal after preliminary local anæsthesia is also of great value, especially in the shorter operations. Cocaine is undoubtedly the local anæsthetic *par excellence* for intra-nasal operations, and may be used alone or in conjunction with adrenalin chloride. It gives excellent anæsthesia of the mucous membranes, but unfortunately many cases of severe or even fatal poisoning have been recorded after the use of cocaine, and some patients appear to be peculiarly susceptible to this drug. Children and old people, as a rule, tolerate it badly, and it must here always be used with the greatest caution. It is probable that in many cases the poisoning is due to the absorption of cocaine which has been swallowed rather than to absorption from the nasal mucous membranes, hence it is most important that pledgets of cotton wool or gauze strips which have been impregnated with the solution should be well squeezed out before application. This tendency to toxic absorption is greatly diminished if adrenalin be added to the cocaine prior to its application. The usual procedure is to use equal parts of 1 in 1000 adrenalin chloride and of the appropriate cocaine solution.

For the purpose of intra-nasal examination a 5 per cent solution of cocaine is sufficient, but for operations a 10 to 20 per cent solution is generally employed. It is said that the addition of a little potassium sulphate to a 5 per cent solution

of cocaine will render it almost as potent as an ordinary 10 per cent solution from an anæsthetic point of view. Solutions of cocaine do not keep very well, and fungoid growths are apt to form in them; this formation may be delayed by the addition of half a grain of salicylic acid to each ounce of the solution. Many rhinologists prefer to keep their cocaine in the form of 5-grain tablets, and to prepare a fresh 10 per cent solution by dissolving one of these in fifty drops of water

Application of Cocaine.

For the minor surgical procedures, such as the use of the electric cautery, it will suffice to insert a pledget of cotton wool which has been impregnated with the cocaine and adrenalin solution and then well squeezed out, and to apply it to the surface which is to be operated upon The pledget should be left in position for ten minutes and then withdrawn; if the nasal mucous membrane be so swollen as to obstruct the insertion of the pledget, a spray of 10 per cent cocaine may be used as a preliminary measure. For the more extensive operations in the nose it is necessary to apply the cocaine solution for a greater length of time. Superficial anæsthesia is first induced by spraying the nasal mucous membrane with a 10 per cent solution of cocaine, the nose then being carefully packed with gauze strips *which have been wrung out in the cocaine and adrenalin solution. These strips* should be left in position for at least half an hour. Many surgeons use Sluder's method of nerve blocking to induce anæsthesia in the nose. A single crystal of cocaine or a drop of a saturated solution is applied to a spot beneath the posterior end of the middle turbinal, and another drop high up on the anterior part of the septum By this means one is able to produce anæsthesia of the areas supplied by the spheno-palatine ganglion and the internal nasal nerve.

Cocaine Poisoning

Reference has already been made to the very real danger of cocaine poisoning, and toxic effects may ensue in spite of all precautions having been taken. In the milder stages there may be merely excitability and restlessness, but in severe cases the patient complains of faintness, tingling of the extremities, and a feeling of precordial discomfort; the face becomes pale, beads of perspiration appear, the pulse becomes thin and rapid, and the pupils markedly dilated. In the worst cases these symptoms pass on to convulsions, cyanosis, delirium, and even to death.

Treatment.

If an idiosyncrasy to cocaine poisoning is known to exist one should take appropriate prophylactic measures, and a preliminary stimulant may be given. Adrenalin should be added to the cocaine solution, and the total amount of cocaine used must be strictly limited. A close watch must be kept on the patient, and at the first sign of untoward symptoms the packing must be removed from the nose. Sal volatile or brandy should be administered, and black coffee to which brandy has been added will prove to be a valuable restorative. In the very severe cases the subcutaneous injection of strychnine or the intravenous administration of phenobarbital has proved of great value.

Cocaine Substitutes.

It is natural that rhinologists have for many years attempted to find a drug which will combine the anæsthetic properties of cocaine and a very low degree of toxicity; unfortunately they have so far failed in their quest. Of the various substances suggested as substitutes those most frequently used are beta-eucaine,

stovaine, procaine, percaine, and novocaine. The latter has but a poor anæsthetic effect when used as a surface application to the mucous membranes, but it gives excellent results when injected submucously. Eucaine is probably the most efficient substitute, and may be employed in patients who show marked susceptibility to cocaine. Its action is slower but more prolonged, but the anæsthesia obtained is less complete, and the degree of vasoconstriction is slight. It may be used either as a surface application or as an infiltration anæsthetic.

I have lately employed a solution prepared by Allen and Hanburys which was originally intended as an anæsthetic for rectal surgery. This consists of procaine 2 per cent, and butyl para-amino-benzoate 5 per cent in ethylene glycol, and has proved efficacious in such operations as cauterisation of the nasal mucous membrane, removal of polypi, and antral puncture. It may also be used for submucous injection, and up to the present no appreciable toxic effects have been detected.

One may here emphasise the importance of preliminary local anæsthetisation even where the patient is to have a general anæsthetic; at the time of operation there will be considerably less bleeding, whilst the field of view will be infinitely improved. It is not out of place, however, to utter a word of warning with respect to the use of adrenalin. This drug when mixed with cocaine for nasal work increases the anæsthetic power of the solution, diminishes the risk of toxic absorption, and by producing ischæmia and contraction of the mucous membranes enables a better view of the field of operation to be obtained. The disadvantages are that:

(1) Reactionary vasodilatation may lead to violent and serious hæmorrhage shortly after the completion of the operation.
(2) Symptoms of acute rhinitis may ensue and persist for one or two days.
(3) Prolonged application of adrenalin may lead to the appearance of a troublesome form of membranous rhinitis
(4) When adrenalin is injected submucously in association, for example, with novocaine it may cause an alarming sensation of palpitation and oppression
(5) The injection of adrenalin submucously when the patient is under the influence of chloroform general anæsthesia may be followed by instant and complete collapse, several fatalities having been reported in such circumstances.

The importance of effective anæsthetisation for intra-nasal work cannot be too strongly stressed. It has been said that with good illumination and good anæsthesia even a mediocre surgeon can obtain excellent results.

GENERAL REMARKS ON INTRA-NASAL OPERATIONS

Pre-operative Measures. It is impossible to render the field of operation aseptic, for any antiseptic which would sterilise the mucous membrane would at the same time cause serious damage. It is, however, possible to wash away any profuse nasal discharge with a mild antiseptic lotion, to cut off projecting vestibular hairs, and to paint the anterior nasal apertures with iodine. Fortunately the normal mucous membrane of the nose appears to be highly resistant to

infection, and such operations as submucous resection of the septum nasi are but rarely followed by local sepsis.

After-Treatment. If possible, this should be conspicuous by its absence. Unless complications arise, the less the nasal cavities have to be interfered with during the post-operative period the better. The complications which most frequently occur are:

(1) Hæmorrhage.
(2) Formation of adhesions in the nose.
(3) Local sepsis.
(4) Infection of the lower air-passages.

Hæmorrhage.

This may be very troublesome at the time of operation, but if the nose has been carefully anæsthetised beforehand the amount of bleeding is usually minimal. Many observers state that the tendency to hæmorrhage is increased with menstruation, but the writer has not found this to be the case. As mentioned above, reactionary bleeding may follow the use of adrenalin, whilst severe secondary hæmorrhage occurring some days after operation may be most alarming. The appropriate measures for the control of bleeding from the nose will be discussed in a later chapter; broadly speaking, it may be said that one should endeavour to avoid packing the nose after operation, especially if pus is present, as prolonged packing tends to promote sepsis, prevent drainage, and interfere with repair of the tissues.

Adhesions.

Adhesions will occur only if opposing mucous surfaces have been injured; good illumination, efficient anæsthetisation, and careful operating are therefore the most important preventive measures. After any nasal operation the patient should be seen within forty-eight hours, commencing adhesions should be gently broken down with a flat elevator, and a small rubber strip should be inserted between the raw surfaces and changed daily until healing has occurred. In cases where there is excessive reactionary swelling of the mucous membrane after operation the likelihood of the formation of adhesions may be decreased by puffing a spray of 5 per cent cocaine and adrenalin 3–4 times daily. If an adhesion forms later it is wise to wait until the fleshy bridge becomes less vascular, when it may be divided by the electric cautery or a diathermy knife.

Local Sepsis.

After intra-nasal operations it is impossible to apply all the principles for the prevention of sepsis which are applicable in the case of ordinary external operations. One cannot dress the wound and thus

protect it from the invasion of micro-organisms, but an attempt must be made to maintain natural drainage. Hence it is important to avoid post-operative plugging of the nasal fossa, especially where there is pus in the nose prior to operation. The retention of the nasal discharges as a result of prolonged plugging is undoubtedly the main cause of septic troubles after operation. If there is excessive formation of mucus or of sloughs, a warm alkaline lotion may be employed as a cleansing agent, but great care must be exercised in its use, as forcible syringing of the nose may lead to acute infections of the Eustachian tube and middle ear.

Infection of the Lower Air-passages.

Such complications are less likely to occur if the operation be performed under local anæsthesia, for in this case the patient may himself prevent blood and secretions from descending into the larynx and trachea. If, however, a general anæsthetic is administered special precautions must be taken to guard against the possibility of direct pulmonary infection. The use of an intra-tracheal tube enables the pharynx and naso-pharynx to be packed off securely, but if an ordinary inhalation anæsthetic is being administered two or more "captive" sponges can be inserted into the naso-pharynx to prevent blood, etc., from entering the pharynx and larynx. Some surgeons consider that they secure further protection by operating with the patient in the Trendelenburg position.

A word of warning may here be given in connection with the use of intra-tracheal anæsthesia. A close watch should be kept upon the respiratory rhythm, and if this becomes at all irregular the anæsthetist must make sure that the tube has not reached the tracheal bifurcation. I have seen three cases of complete collapse of the left lung in such circumstances, probably due to the fact that the tube had entered the right bronchus and thus occluded the opening of the left bronchus.

CHAPTER II

Injuries and Diseases of the External Nose

Fractures of the nasal bones are of common occurrence, and motor-car accidents have in recent years been responsible for an increase in their frequency. When due to blows received in boxing, football, etc., the deformity is usually a lateral one, but in car accidents the nasal bones may be driven almost directly backwards, and tend to be impacted between the nasal processes of the superior maxillæ. In some instances the nasal processes of the superior maxillæ may themselves be depressed, whilst in the more serious cases there may be severe injury to the frontal bones, the bodies of the superior maxillæ, and the cribriform plate.

According to Mosher the usual sites of fracture of the nasal bones are:

(1) At the attachment to the nasal processes of the superior maxillæ.

(2) In the middle line, at the attachment to the septum and to the opposite nasal bone.

(3) At the junction with the nasal process of the frontal bone.

Diagnosis.

It is usually possible to make a diagnosis without the aid of skiagrams, but these are often of value in complicated fractures. In many cases there is a rotation displacement, and it is most important that this should be corrected (fig. 2538).

Palpation may elicit the presence of crepitus, but one must be careful to distinguish between true bony crepitus and the air crepitus which is a frequent accompaniment of injuries to the nose. A careful examination through the nasal speculum should always be made, and a large aural speculum is often an excellent substitute for the nasal speculum, especially in children who object to the pain caused by the pressure of the blades of the latter.

Anæsthesia.

Reduction of the deformity may be effected by manipulation without anæsthesia in the simpler cases, but it often pays to pack the nasal cavities with a local anæsthetic for a short time beforehand. Infiltration anæsthesia is unwise in

recent fractures on account of the excessive swelling which is usually present. If a general anæsthetic is to be administered, the use of gas alone is in most cases insufficient.

Instruments.

For the elevation and replacement of the fractured bones numerous instruments have been devised, and Asch's or Walsham's forceps are of particular value. In an emergency, however, one may make use of ordinary artery forceps

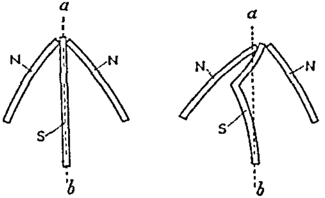
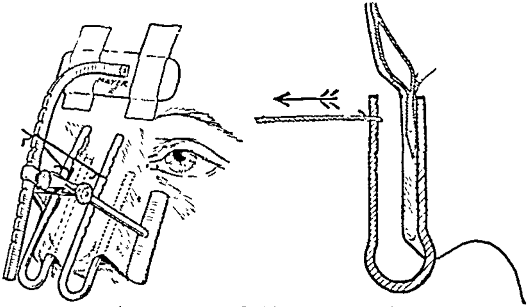


Fig 2538.

THE FIGURE ON THE LEFT SHOWS DIAGRAMMATICALLY THE NORMAL POSITION OF THE NASAL BONES AND SEPTUM, THAT ON THE RIGHT SHOWS THE ROTATION DISPLACEMENT WHICH COMMONLY OCCURS IN FRACTURES.

a—*b* Mid line of nose
N Nasal bone
S Septum

(*After Watkins*)



A. *Fig* 2539. B.

WATKINS' NASAL SPLINT, SHOWING SPLINT APPLIED. THE DIAGRAM ON THE RIGHT SHOWS THE PRINCIPLE OF APPLICATION OF ANTERIOR TRACTION

with a piece of rubber tubing over the ends, of the flat end of a tongue depressor, or of the flat handle of a nasal rasp. The displaced nasal bones are elevated and any rotation corrected; in many cases no splint will be required, but if the displacement tends to recur, some form of internal or external splint must be employed. Many forms of such splints have been devised, including the ordinary copper-moulded splints, Watson-Williams' triangular splint, Gillies' dental splint, and Walsham's adjustable external splint with headband. For the more extreme fractures, accompanied by comminution and marked depression of the bridge, Watkins' splint (fig. 2539) is of great value. It is a modification of Carter's splint,

and has the obvious advantage of not necessitating the perforation of the nasal soft tissues by silk threads. One limb of a metal U-shaped splint is inserted into each nostril, and anterior traction is applied by a silk thread tied to a notch on the outside limb opposite the middle of the nasal bone. The rest of the splint consists of a hinged arch with rubber-covered bases which rest on the cheeks. A mast from a hinged forehead plate, which is held in place with adhesive strapping, can be adjusted to the apex of the arch with a screw. The silk threads from each of the U-shaped splints are tied to one another over one of the notches on the mast, the notch being selected which will allow traction to be exactly at right angles to the nasal bones. After these threads have been tied, tension can be adjusted by a screw, which alters the angle between the limbs of the arch. When the splint is in use nasal respiration is still possible.

After-care is important, and a watchful look-out must be kept for any signs of slipping or displacement.

Old Fractures with Deformity.

The correction of such deformities really comes within the scope of cosmetic surgery, and as such is treated elsewhere, but a few remarks will not here be out of place. In the first instance one may emphasise the frequent necessity for performing a submucous resection of the septum in addition to the appropriate plastic operation. The majority of these operations may be carried out under local infiltration anæsthesia.

For the correction of lateral deformities an incision is made inside the vestibule of the nose, the periosteum and the soft structures are elevated over the sides and dorsum, and the bones are re-fractured by means of a saw or chisel, and then moulded into the desired position. Some form of external splint is applied, a small rolled bandage held in place on each side of the nose being a simple and serviceable form of such splint.

In the case of depressed fractures it is now usual to insert a graft prepared from a portion of rib cartilage. The injection of paraffin wax to correct this type of deformity has been abandoned. The insertion of the rib cartilage graft is a comparatively simple procedure, and gives excellent cosmetic results. The columellar incision advocated by Gillies enables one to prepare a bed for the graft by burrowing beneath the skin of the dorsum of the nose; the graft, which is taken from the 7th, 8th or 9th rib, is shaped so as to correct the depression, and is then pushed into position in its bed. The columellar, or "elephant-trunk," strip is finally sutured, and leaves no visible scar. In performing this operation the beginner is apt to make two errors: in the first place, he tends to endeavour to insert too large a piece of cartilage; secondly, he is liable to drop the graft upon the theatre floor when transferring it to the nose. I have on two occasions been guilty of this

crime, and now take the most stringent precautions to prevent a recurrence.

In cases where the nasal tip is also depressed, use is made of an angled cartilage graft, the shorter limb of which is kept in place by the columellar strip.

Whilst discussing the question of cartilage grafts it may be well to mention the treatment of collapse of the alæ nasi. This condition can be markedly alleviated by the use of Francis nasal props, which are invisible when *in situ*, but excellent results have also followed the insertion of small portions of auricular cartilage or of thin rib cartilage grafts.

External Infections of the Nose.

These should be treated with the greatest respect, as the danger of the supervention of septic thrombosis of the cavernous sinus is a very real one, and many deaths from this cause have been recorded. Bathing the part with hot lotion, or the application of compresses of a saturated solution of magnesium sulphate, may abort the process; incisions should not be made unless pus is obviously present, and in no circumstances should one endeavour to squeeze a boil on or about the nose. It is fortunate that after plastic operations upon the nose bad sepsis is seldom encountered, and even if sepsis does occur the cavernous sinus appears to be remarkably free from liability to infection. In cases where local suppuration does occur, aspiration with a needle will usually bring about a cure, but in some instances it may be necessary to incise and drain the abscess-cavity.

CHAPTER III

Surgical Diseases of the Nasal Septum

HÆMATOMA OF THE SEPTUM

It is probable that this condition occurs much more frequently than is generally recognised, and the writer has on several occasions found it present when patients have been sent up with a provisional diagnosis of polypus or septal deflection. Hæmatomata are usually the result of falls or blows on the nose, but they are also liable to follow the operation of submucous resection of the septum unless suitable measures are taken to prevent their occurrence. Septal hæmatomata cause marked nasal obstruction, and may be accompanied by a considerable degree of pain; they are liable to become infected and thus lead to the formation of a septal abscess. In the treatment of hæmatomata cold evaporating lotions should be applied externally, and the nasal cavities sprayed with cocaine and adrenalin; such measures may effect absorption, but where the swelling is very large and tense it may be safer to incise it.

ABSCESS OF THE SEPTUM

The secondary infection of a hæmatoma is the commonest cause of a septal abscess, but it may follow intra-nasal operations upon infected sinuses where the mucous membrane of the septum has been injured. Cases of idiopathic origin have also been recorded as a secondary manifestation of such diseases as typhoid fever, syphilis, tubercle, small-pox and erysipelas.

The usual symptoms are severe pain and marked nasal obstruction. The pain is often throbbing in nature, and the nose becomes very tender to the touch.

Diagnosis.

Hæmatomata and abscesses of the septum are common in children, and a careful examination with an aural speculum will enable a correct diagnosis to be made; in adults the condition must be differentiated from a breaking-down gumma. The latter usually ulcerates rapidly, and tends to attack the bony septum, whilst an abscess is situated in the anterior part of the cartilage and is much more painful and inflamed.

Treatment.

Once the condition has been diagnosed prompt treatment is essential. A horizontal incision is made at the lowest part of the swelling on both sides of the septum, and any loose fragments of cartilage are removed. After-treatment is important, and consists in passing a probe into the lips of the incisions to ensure that there is no re-accumulation of pus.

Prognosis should always be guarded, as unfortunate sequelæ may result despite prompt surgical intervention. Necrosis of the septal cartilage is of relatively common occurrence, and may be followed by a permanent perforation of the septum. Later, a marked external depression of the bridge or tip of the nose may appear, and in children the development of the nose is sometimes seriously interfered with.

DEFORMITIES OF THE SEPTUM

It must be remembered that some degree of septal deformity is the rule rather than the exception amongst the civilised peoples, but in only a small proportion of cases does the deformity cause symptoms sufficient to require correction. Someone has stated that " it is a poor nose that isn't worth a fiver," and many a septum has undoubtedly been attacked where the justification has been anatomical rather than clinical.

Morell Mackenzie, in an examination of the skulls in the Museum of the Royal College of Surgeons, found that 1657 out of 2152 (nearly 77 per cent) showed some degree of deformity of the bony septum, and Zuckerkandl and other observers have confirmed his findings. That the deformity should be so common is amazing, and the ætiology of the condition is of great interest. It is certainly much more frequently found in civilised than in savage peoples, a fact which seems to indicate that traumatism cannot be the main predisposing cause. It has been noted that deflections of the nasal septum are almost invariably accompanied by high arching of the palate, which, in its turn, is nearly always due to the presence in childhood of some form of nasal obstruction. The septum is situated between two unyielding structures, the base of the skull above, and the palatal bones below, and if the vertical depth of the nasal cavity be diminished owing to the presence of a high-arched palate it is evident that the septum must develop a deviation to one or other side during its growth. Now in children the most frequent cause of nasal obstruction is the presence of adenoids, and it is therefore probable that the main ætiological factor in the causation of deformities of the septum is the failure to deal with the obstructive adenoid pad during the period of skeletal growth. In these circumstances the early

relief of any cause of nasal obstruction in a child is obviously of the utmost importance.

Symptoms of Septal Deformities.

The great majority of deformities of the nasal septum produce no ill-effects, but in some cases they may cause troublesome or even serious symptoms. The patient usually complains of some degree of nasal obstruction, and of the symptoms which follow such obstruction. These latter are, in short, chronic rhinitis, pharyngitis, laryngitis, tracheitis, headache, aprosexia, and loss of nasal resonance with alteration of the timbre of the voice. There are, however, other symptoms which depend upon the abnormality itself; the chief of these are:

(1) External deformities of the nose.
(2) Obstinate headache and neuralgic pain. This may be due to direct pressure of a turbinal against the deviated septum, or to interference with the proper aeration of one of the accessory sinuses, especially the fronto-ethmoidal. The so-called "vacuum" headache is a good example of this.
(3) Hay fever, asthma, and paroxysmal sneezing which, in certain cases, appear to be caused by such deformities as septal spurs.
(4) Epistaxis. The bleeding is secondary to the formation and separation of crusts, and may occur on an anterior convexity or in the pocket of a deep depression on the concave side.
(5) Mechanical obstruction of one or more of the openings of the paranasal sinuses.

The association of chronic otitis media with deviations of the septum should not be forgotten. This is a result of the chronic rhinitis which is frequently present, and is probably due to the persistent hyperæmia of the nasal mucous membrane which occurs behind the obstructed part. This in turn leads to a chronic inflammation of the lining of the Eustachian tubes and the middle ears.

Diagnosis.

This should not be difficult if the nose is carefully examined with a probe after cocainisation. Where the deviation results in one side of the nose being much more roomy than the other it is usually to be noted that the inferior turbinal on that side is greatly hypertrophied; in such cases it is obvious that treatment of the enlarged turbinal alone will be ineffective.

Treatment.

As has been stated above, the majority of septal deformities require no operative attention, but active treatment is called for when the following conditions are present:

(1) Marked nasal obstruction associated with such *symptoms* as chronic otitis media, chronic rhinitis, pharyngitis, laryngitis or bronchitis, especially if the patient be liable to repeated acute attacks of these conditions. In those cases where unilateral atrophic rhinitis is present on the roomy side of the nose a submucous resection may cure the disease by equalising the airway through both nostrils.

(2) External nasal disfigurement, where this is due to the deviation of the cartilaginous part of the septum.

(3) Nasal neuroses such as hay fever, asthma, or paroxysmal sneezing, where no other predisposing cause is discovered, and where the condition is obviously aggravated by the deviation.

(4) Those cases where the deflected portion of the septum interferes with other intra-nasal treatment, such as the removal of polypi, the passage of a Eustachian catheter, or the exploration and treatment of an accessory nasal sinus.

(5) Epistaxis originating in the depths of a small pocket, or from a widespread area of mucous membrane which does not respond to repeated cauterisation.

Operative Technique.

Submucous resection of the septum has now entirely replaced all other methods devised for the correction of septal deformities, and for this method of removing the obstruction without sacrifice of the mucous membrane we are chiefly indebted to the pioneer work of Killian. Freer, Ballenger and other surgeons have suggested technical improvements, but the principles propounded by Killian remain unchanged.

In the majority of cases it is preferable to operate under local anæsthesia alone, but for very nervous patients a general anæsthetic is advisable, and this is especially the case where the posterior part of the bony septum has to be dealt with. Even when a general anæsthetic is to be administered it is essential to effect preliminary local anæsthesia; by such means the surgeon will obtain better visibility, and hæmorrhage during the operation will be markedly diminished. Local anæsthesia is induced in the manner already described, although some operators do not use the method of packing the nose, but rub over the whole mucous membrane with *cotton-wool applicators impregnated with equal parts* of stronger solutions of cocaine and 1 in 1000 adrenalin. The full anæsthetic effect of cocaine is not obtained in less than 40 to 45 minutes; at the end of this time the packing (if used) is removed, and a submucous injection of 1 per cent procaine, or equal parts of 2 per cent

novocaine and 1 in 5000 adrenalin, is made in the area of the proposed incision. It is, as stated above, impossible to effect sterilisation of the field of operation. but some operators paint the nostrils, nose and lips with iodine before commencing the operation, and cover the patient's face with a sterile gauze mask containing an opening for the nose. The patient's head and shoulders are raised, a manœuvre which facilitates manipulation in the nose, and also tends to diminish intra-nasal congestion and consequent bleeding. If bleeding is likely to occur small cotton-wool swabs may be used. but a better method is to employ a suitable suction apparatus. Efficient illumination is a *sine qua non*; reflected light from a head mirror is most satisfactory for this operation, or an electric headlamp may be worn. The nostril on the side of the

Fig 2540.—The convexity of the septum, the inferior turbinal, and the line of incision are shown.

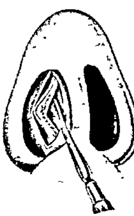


Fig 2541.—Depicting the edge of the septal cartilage and the elevator.

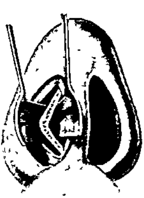


Fig. 2542.—Killian's long speculum inserted with one blade on each side of the deflected septal cartilage.

septal convexity is held open with a small Thudichum speculum, and an incision is made through the mucous membrane and muco-perichondrium down to the cartilage. This incision is situated slightly in front of the anterior part of the deviation, and should extend from high up on the septum to within a quarter of an inch of the nasal floor (fig. 2540). Where there is a marked inferior septal spur it is often wise to carry the incision horizontally backwards for about half an inch, as there is then less liability of tearing the mucous membrane when this is being separated from the spur. For the purpose of making the initial incision many different forms of knife have been devised; the writer uses either a small tenotomy knife or Freer's model. The incision is slightly convex in a forward direction, and should be so placed as to leave sufficient cartilage in front to support the tip of the nose and the columella when the deflected portion of the septum has been removed. A suitable

elevator is then inserted between the muco-perichondrium and the cartilage, and the muco-perichondrium is carefully "lifted" off the cartilage over the whole extent of the cartilaginous deviation. This is accomplished by sweeping the elevator firmly upwards and downwards as well as backwards, care being taken to ensure that the elevator is kept in close and firm contact with the cartilage. It is of the utmost importance that the separation should be between the cartilage and the muco-perichondrium or great difficulty will be encountered in avoiding lacerations when raising the mucous membrane; moreover, if the muco-perichondrium is left attached to the cartilage, the resulting membranous septum will be weak, and apt to flap with nasal respiration.

The next step consists in cutting through the cartilage in the line of the original incision, care being taken to avoid penetrating the muco-perichondrium of the opposite, or concave, side. A finger placed against the mucous membrane of the concave side will help to guard against this danger, and the knife is held at an angle as if to "lift" the cartilage away from its covering mucous membrane. It has been suggested by Watson-Williams that a small incision be made on the concave side well in front of the site selected for the incision on the convex side, and the muco-perichondrium so elevated that when the knife cuts through the cartilage it does not cause a perforation, but merely pushes the loosely detached membrane before it. Once the cartilage has been divided, a suitable elevator is passed through the *incision and introduced between the cartilage and the muco-perichondrium* of the concave side (fig. 2541). The separation is then carried out as on the convex side, but it must be remembered that the mucous membrane covering the concavity is often thin and friable, and may be so adherent as to render its separation extremely difficult. It is at this stage that perforation is apt to occur, and great care must be taken to obviate this. The use of a sharp-edged elevator will facilitate the dissection of the mucosa where it is particularly adherent to the cartilage. In the more difficult cases the operator must exercise the greatest patience; where it is impossible to see beyond the apex of the convexity he should first remove only a small anterior portion of the cartilage, and then under direct vision complete the elevation of the mucosa. When this elevation from the cartilage has been completed, a long-bladed Killian speculum is inserted between the elevated muco-perichondrial layers in such a manner that the cartilage is included between the blades (fig. 2542). A Ballenger swivel knife (see fig. 2543) is then introduced near the upper end of the cut cartilage, and pushed upwards and backwards parallel to the nasal bridge until it reaches the

bony part of the septum. It is then pressed downwards until it comes into contact with the vomer, when it is pulled forwards in a direction parallel to the nasal spine of the superior maxilla. A roughly quadrilateral segment of cartilage is thus detached, and is removed with Killian forceps. The resultant cavity between the flaps is mopped or sucked clear of blood, and the cut edge of the septum is carefully inspected. If, as is probable, it is seen that the deviation has not been entirely corrected, one must proceed to remove a portion of the bony septum as well as any remaining cartilaginous deflections. The affected area must be denuded of its muco-periosteum, for which purpose Freer's

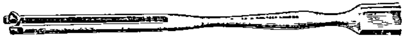


Fig. 2543.—BALLENGER'S SWIVEL KNIFE FOR SEPTAL CARTILAGE.

bent knife is very useful, and the bony septum is removed with punch forceps until the deviation has been corrected (fig. 2544). Cartilage attached to the vomer or to the maxillary spine may be cut away with a chisel, whilst the upper rim of the cartilage should have any remaining deflection nibbled away with punch forceps. It is frequently found that this upper rim bends strongly towards the side of the original convexity, and, if left, will prevent the membranous septum from hanging

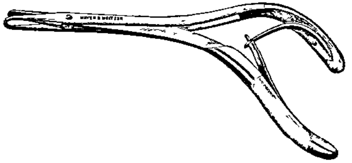


Fig. 2544.—FOSTER-BALLENGER'S SEPTAL PUNCH FORCEPS.

down in the middle line. At the same time one must be careful to leave a sufficient strip of cartilage both superiorly and anteriorly to ensure support and prevent sinking-in of the nasal bridge or tip (fig. 2545). When removing the deviated portion of the perpendicular plate it is important to bite it away with punch forceps, and not to twist and break it, as the latter procedure is liable to cause injury to the cribriform plate.

The operator will now find that he has to deal with the vomer and the maxillary spine. In the great majority of cases a pyramidal, or limpet-shaped, bony thickening is present at the ethmo-vomerine junction, and failure to remove this will militate against the success of

the operation from a clinical standpoint. The muco-periosteum must be carefully raised from the bony projection on all sides, and the "pyramid" is then twisted out by means of a pair of Killian forceps. The thickened maxillary spine must also be stripped by sharp dissection, after which it is removed with a gouge or with Wood's special

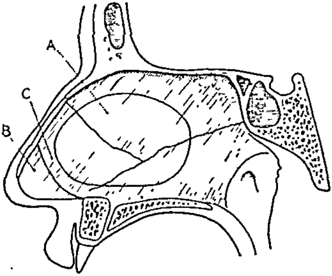


Fig. 2545.

A Area of cartilage and bone removed in ordinary submucous resection of the septum

B. Area of cartilage removed to correct anterior dislocation of the septal cartilage

C "Bowsprit" of cartilage which must be left to prevent depression of tip of nose

forceps (fig. 2546). During the removal of this spine the naso-palatine artery is liable to be injured, which may cause very troublesome hæmorrhage.

The long-bladed speculum is then removed, the flaps are allowed to fall together, and a careful examination is made to ensure that the nasal obstruction has been remedied; it is particularly important to

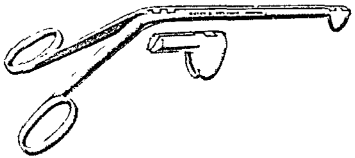


Fig 2546.—Wood's cutting forceps for maxillary crest.

make certain that no obstruction persists in the upper and middle passages of the nose. The speculum is again inserted between the flaps, and any loose fragments of cartilage or bone are taken away with forceps. The flaps are then allowed to fall together, and packing is inserted into each nasal cavity to ensure that the raw surfaces of the flaps are kept in apposition in order to minimise the risk of formation of a hæmatoma. I use long strips of narrow ribbon gauze which are packed into two fingers cut from an ordinary rubber glove. The

fingers are dipped in liquid paraffin, and their removal causes no pain or trauma; after 24 hours the packing is withdrawn from the fingers, and these are then slid gently out of the nose.

Some surgeons suture the original incision at the end of the operation, whilst others claim that superior end-results are obtained if as much septal cartilage as possible is replaced between the muco-perichondrial flaps; the writer has followed neither of these practices.

Dislocation of the Anterior End of the Triangular Cartilage.

This deformity is often found to be associated with a well-marked convexity of the main part of the septal cartilage to the opposite side; consequently there is obstruction of one nostril anteriorly and of the other further back. In such cases it is essential to relieve both obstructions, but an intervening column of cartilage must be preserved in order to obviate flattening of the nasal tip. The usual procedure is to deal with the posterior part in the manner described above, and then to remove the dislocated anterior portion. This is effected by making a vertical incision with a small tenotomy knife, separating the muco-perichondrium from the cartilage with a sharp Freer elevator, and removing the dislocated cartilage with scissors or a knife. It may here be of advantage to insert a suture in the cut edges of the mucous membrane (see fig. 2545).

In those cases where the inferior turbinal on the concave side is markedly hypertrophied it may seem advisable to amputate its anterior end at the conclusion of the septal resection; this procedure, however, greatly increases the liability to the formation of post-operative adhesions, and the general practice is to defer operation upon the turbinal until the muco-perichondrial septum is soundly healed. The anterior turbinal end may be amputated, or its turgescence reduced by the application of the electric cautery.

After-Treatment.

The plugs are removed 24 hours after the operation, and in most cases no special after-treatment is required. Should there be excessive reactionary swelling, a spray of 5 per cent cocaine with adrenalin, or inhalations of Friar's balsam with menthol, will give considerable relief. The patient should be warned that it will be at least three or four weeks before he feels the full benefit of the operation.

Results of Operation.

If the cases are properly selected the functional results are usually excellent, but it must be borne in mind that in those cases which really require operation the technical difficulties are considerable; fortunately the operator often finds that great relief is finally afforded

when he has been rather disappointed with the anatomical appearance at the end of the operation. At other times the patient complains that his nose is " as bad as ever," and this is probably due to the persistence of a chronic rhinitis, though in many cases it is the result of the operator overlooking the presence of pre-existing collapse of the alæ nasi.

Occasionally very unpleasant sequelæ may supervene, the two main ones being hæmorrhage and pyogenic infection. The hæmorrhage can be most alarming, and if prolonged nasal plugging is required to promote its arrest septic complications are almost sure to follow. The writer remembers with good reason one such case where an acute pansinusitis and bilateral acute suppurative otitis occurred as a result of the treatment of intractable hæmorrhage; in this patient a blood-transfusion fortunately gave magical relief, and within twenty-four hours the symptoms had almost completely disappeared. It is especially important not to perform the operation if the patient is suffering from influenza or an acute catarrhal infection, as numerous cases have been recorded of subsequent tonsillitis, acute otitis media, mastoiditis, septicæmia, and even cavernous sinus thrombosis.

Of the less serious after-results the most common is a septal perforation, which as a rule causes no symptoms. If, however, the perforation is large it may lead to the formation of dry crusts in the nose, whilst if it is small and situated in the anterior part of the septum it may produce an irritating whistling noise during respiration, and thus prove to be a distinct social drawback.

The advisability of performing this operation upon young children must be considered, in view of the possibility of interference with the normal growth and development of the nose. Except in special cases, such as excessive external deformity, the writer makes a practice of postponing the operation until later adolescence is reached, but many surgeons, including Freer and Killian, maintain that the risk of maldevelopment is a very small one. It should, however, be remembered that operation in a child's nose is not an easy matter, and if the deformity recurs subsequent operation is rendered doubly difficult owing to the presence of scar tissue. The ætiological importance of adenoids as a factor in the production of septal deformities must not be forgotten, and a careful examination of the post-nasal space, if necessary under a general anæsthetic, should never be omitted in cases of nasal obstruction in children.

Perforations of the Septum.

Perforations of the bony septum are usually due to syphilis, but we are here more concerned with the traumatic perforations which almost

invariably occur in the cartilaginous portion. The perforating ulcer occurring in rhinitis sicca is comparatively common, but the cartilage may be perforated as a result of a septal abscess, or during operations upon the septum. If, during the performance of a submucous resection, the mucous membrane on the concave side is torn, the surgeon must withdraw the elevator and carefully introduce a sharp-edged separator, which he keeps pressed closely against the cartilage until he has regained the correct plane.

The treatment of septal perforations is rarely called for, but if troublesome symptoms occur operation may be required. Some form of mucosal graft is employed but the results have on the whole been disappointing.

Septal Adhesions.

These may be present as a result of traumatism or disease. They are most commonly found between the septum and the inferior turbinal, but may occur between the middle turbinal and the septum.

Symptoms. In a large majority of cases there are no symptoms, but broad short bands may cause a considerable degree of nasal obstruction, and neuralgic pains are sometimes complained of.

Treatment. Treatment is called for only if the symptoms are troublesome, or if the presence of the adhesions prevents the performance of necessary intra-nasal operations. The bands should be divided with scissors, or destroyed by means of the electric cautery or, preferably, by diathermy. It will sometimes be necessary to perform a partial turbinectomy, or to correct the septal deflection by submucous resection. After any such procedure the raw surfaces must be kept apart by a rubber or celluloid splint, and any tendency to the re-formation prevented by the occasional passage of a probe until complete healing has resulted.

CHAPTER IV

EPISTAXIS

BLEEDING from the nose is frequently met with, and may be due to local pathological conditions in the nose, or to general causes. Large lists of such causes are to be found in almost all text-books on diseases of the nose, but here only the most common will be dealt with. For a comprehensive list the student is advised to consult St. Clair Thomson's excellent work, *Diseases of the Nose and Throat.*

Epistaxis is but rarely present in infancy, but is very common from the age of 3 to 4 years up to puberty, and in such cases is frequently due to the presence of adenoids. It is comparatively rare in middle life, but tends to occur more often in advanced age when it is of more serious import. Statistics have shown that in about 90 per cent of all cases of epistaxis the bleeding-point is situated on the antero-inferior surface of the cartilaginous septum, about a quarter of an inch from the vestibule and the same distance from the floor of the nose. This area was first described by an American surgeon named Little, but owing to the well-known preference of the English for foreign-sounding names, it is usually referred to as Kisselbach's area. In this position one frequently sees a varicose leash of vessels, while at other times a small spouting branch of the naso-palatine artery may be observed. Epistaxis may also arise further back in the nose from the septum or turbinals, from an artery in the floor of the nose, or from the anterior or posterior ethmoidal veins. One must also mention the bleeding which occurs from the so-called "bleeding polypus of the nose," and that associated with malignant nasal growths.

Diagnosis.

This is usually easy if a good view of the nose can be obtained, but it must be remembered that the blood often runs into the naso-pharynx and pharynx, whence it may be vomited or coughed up, and thus give rise to suspicions of the presence of gastric or pulmonary disease. In the same way blood from the pharynx, stomach or lungs may escape through the nose and lead to a false diagnosis of epistaxis being made. In cases of bleeding from the nose following trauma the possibility should not be overlooked of a fracture of the base of the skull having occurred.

Prognosis.

This naturally varies according to the prime cause of the bleeding. When due to some constitutional cause the prognosis depends upon the nature of such cause; when due to a purely local condition it is usually good, unless the epistaxis is secondary to malignant disease or to an inoperable fibroma. It should be noted that hæmorrhage from an ordinary nasal polypus is not a common symptom. In elderly people the occurrence of epistaxis may suggest the probability of a subsequent cerebral hæmorrhage, for, like sub-conjunctival hæmorrhage, it often signifies the existence of degenerative changes in the walls of the blood-vessels accompanied by a raised blood-pressure.

Treatment.

In old people epistaxis is often a safety-valve, and in the majority of cases no attempt need be made to arrest it. When due to general diseases the tendency to epistaxis may be diminished by suitable treatment of the causative condition. If, however, the bleeding becomes excessive one may be forced to adopt local measures to ensure its arrest. Loosening of the clothes around the neck, and the application of iced water to the bridge of the nose may be effective; if the epistaxis persists, a cotton-wool tampon soaked in a solution of adrenalin or of hydrogen peroxide may be introduced into the nostril, and pressure then be applied upon the ala nasi of the same side. The tampon is left in position for from 12 to 24 hours, at the end of which time the bleeding has usually ceased. Should the hæmorrhage still persist, the nose must be packed; the nasal mucous membrane is painted with a 5 per cent solution of cocaine, and then, under efficient illumination, the nasal cavity is carefully packed from below and behind upwards and forwards with ribbon gauze. Such packing should not be left in place for more than 24 to 36 hours for fear of the supervention of sepsis, and its removal should be effected gently in order to prevent a renewal of the bleeding. If a Cooper Rose bag be available it may be used instead of gauze packing, its advantages being that it is more easily inserted and removed, whilst its removal is less likely to be followed by renewed bleeding. The bag is introduced in the collapsed state until the end reaches the posterior choana, when it is inflated as tightly as possible, and the stopcock closed. To effect its removal the stopcock is opened, and the deflated bag can then be easily and painlessly taken out of the nostril.

In the more obstinate cases it may be found necessary to pack both the nose and the post-nasal space. For many years this was done by means of a Bellocq sound, but a small soft rubber catheter makes an excellent substitute. The packing consists of a sponge or a tampon of

lint, to which two long strings or tapes are attached. The catheter is passed through the nostril until it is seen behind and below the soft palate, the tip is then drawn forward and one of the strings firmly tied to it. The catheter is now pulled back through the nose until the string can be grasped, when the tampon is drawn tightly into the posterior choana. The string from the nose and that from the mouth are then tied together, and the anterior nares packed with ribbon gauze. The packing and tampon must be removed within 24 to 36 hours, gentle syringing with a solution of bicarbonate of soda considerably facilitating the process.

When the bleeding originates from Little's area, a cure is often effected by obliteration of the varicose vessels with the electric cautery, or with chromic acid or trichloracetic acid. Where a large area of the mucous membrane is affected, the cautery may be ineffective, and in these circumstances it may be necessary to dissect the mucosa off the septal cartilage, or even to perform a submucous resection of the cartilage itself. A resection may also be required when the bleeding comes from the depths of a concavity far back on the septum.

In the case of children, who support badly such intra-nasal operations as the application of the cautery, the local treatment of epistaxis often provides a difficult problem. Asherson has suggested the submucous injection, under general anæsthesia, of a solution of sodium morrhuate, or of 10 per cent phenol in almond oil, in such cases, and I have found this method to be of considerable value on several occasions. (Asherson, *Journal of Laryngology and Otology*, 1934, XLIX, 180-81.)

In the most serious cases of epistaxis, which persist in spite of all other treatment, it may be necessary to give a transfusion of blood.

Finally, a practical "tip" may here be given in connection with the cauterisation of a bleeding-point in the nose. If, when the suspected area is touched with the cautery-point or the probe, fairly brisk bleeding does not occur, it is probable that the offending vessel has not been found, and a careful search of the remainder of the nasal cavity, especially of the floor, should be made.

FOREIGN BODIES IN THE NOSE

Foreign bodies may enter the nasal cavities:

(1) Through the nostrils.

(2) Through the posterior choanæ.

(3) By penetrating one of the nasal walls.

They may also arise in the nose itself, for example, in the form of bony sequestra or rhinoliths.

Children provide the vast majority of cases, as they are apt to push into their nostrils such objects as buttons, peas, beads, fruit-stones or small pebbles. Small pellets of rolled-up paper also appear to exert a fatal fascination for them. In adults the patients are usually lunatics or hysterical women, but the foreign body is occasionally found to be a piece of gauze or wool which has been inserted during treatment and

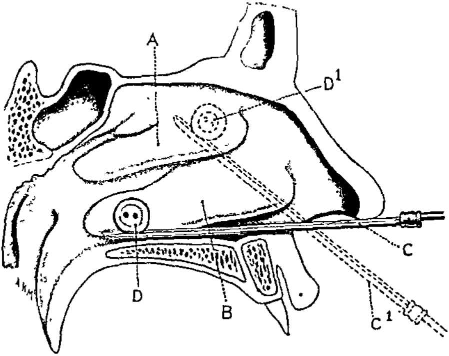


Fig. 2547.—DIAGRAM TO SHOW THE METHOD OF REMOVAL OF A FOREIGN BODY FROM THE NOSE BY MEANS OF A GROOVED DIRECTOR

A. Middle turbinal. B. Inferior turbinal. C. Narrow grooved hernia director. D. Foreign body. C[1] and D[1] show positions of director and foreign body during removal.

then forgotten or only partially removed. In the tropics maggots and various parasites may take up their residence in the nasal cavities.

Foreign bodies which penetrate the nasal walls are usually bullets or fragments of high-explosive shells, and these may be accompanied by pieces of the uniform or of a steel helmet.

Symptoms.

These may be slight, unless the foreign body has been in the nose for a long period, when it produces a unilateral purulent discharge which may become offensive and blood-stained. Headache and earache often ensue, and there may be a considerable degree of nasal obstruction.

Diagnosis.

This may occasionally present considerable difficulty, especially if the foreign body has been *in situ* for a long time; but careful examina-

tion with a probe under local anæsthesia will usually lead to the detection of any foreign body which may be present. In the case of children a general anæsthetic is advisable even for examination, but the necessary instruments should be at hand in order that immediate extraction of any foreign body may be effected.

Treatment.

Removal of the offending foreign body is essential, but may prove to be extremely difficult. Any attempt at blind extraction is dangerous and probably ineffective, whilst such methods as syringing of the nasal cavity or politzerisation through the opposite nostril must be condemned as likely to lead to acute infection of the middle ears. It is essential to have the best illumination possible, and effective local or general anæsthesia must be induced. The best instrument with which to effect removal is an ordinary narrow hernia director. This is gently pushed along the floor of the nose until the distal end reaches just beyond the foreign body; the handle of the director is then depressed, the floor of the vestibule acting as a fulcrum, and the foreign body is displaced forwards in the groove of the director, and appears at the anterior nasal aperture (fig. 2517). The simplicity and efficacy of this method have been proved upon many occasions, and it is especially good in the case of such foreign bodies as peas, beads or small pebbles, which have such an annoying tendency to slip further back in the nose when an attempt is made to grasp them with forceps. In most text-books the use of a bent probe, buttonhook, strabismus hook, or forceps with serrated blades is recommended; on one occasion I derived great satisfaction from inserting a buttonhook into the eye of a boot button and thus extracting the button.

If forceps are employed, great care must be taken to avoid pushing the foreign body back into the naso-pharynx lest it should fall into the larynx. If such an accident be feared, it may be prevented by passing a finger through the mouth and into the appropriate posterior choana.

Rhinoliths may be dealt with in the above manner, whilst maggots are brought away by the use of oil or chloroform in the nose.

CHAPTER V

Minor Operations in the Nose

The chief forms of minor intra-nasal operations are:

(1) Cauterisation.

(2) Removal of hypertrophied or diseased structures.

Cauterisation is effected by means of chemical caustics or the galvano-cautery. Of the former the most suitable agents are chromic and trichloracetic acids. Either may be used to reduce swelling of the mucosa, or as an application to arrest epistaxis, but the chromic acid has the more powerful destructive action upon the mucous membrane. They may be applied in strong solutions by means of cotton wool twisted round the end of a suitable narrow carrier. It is essential to wipe away any excess of the acid. Some operators prefer to use the pure crystals after fusing them on a probe.

The galvano-cautery has proved extremely useful for the destruction of redundant tissue in the nose, for effecting counter-irritation as in cases of hay fever, and for obliterating the vessels giving rise to spontaneous epistaxis. The cautery may be worked from a dry or wet cell, or, by means of a transformer, from the ordinary house current. The charge must be so regulated that when the trigger of the holder is pressed the platinum burner glows at a cherry-red heat; if too much current is used, the action of the burner is rapid and difficult to control, and troublesome bleeding may ensue, whilst if only a dull red heat is generated the cautery-point tends to adhere to the mucous membrane, and thus cause laceration when it is removed.

It is, of course, essential that the nose be well anæsthetised before any attempt at cauterisation is carried out, and good illumination is also necessary; in no circumstances must the cautery-point be applied to any area in the nose which is hidden from the view of the operator.

It must be remembered that certain dangers may be associated with the use of the electric cautery in the nasal cavities. Adhesions are prone to follow its unskilful application, or sepsis may supervene and lead to such complications as acute tonsillitis and acute otitis media. Moreover, the use of the cautery in the ethmoidal region has been known to

be followed by the appearance of such dread sequelæ as facial erysipelas, septicæmia, and even meningitis. The latter is probably due to infection passing up through the cribriform plate via the ethmoidal veins. Deep cauterisation should therefore never be employed for the middle turbinals or other ethmoidal structures, though it is probably safe to cauterise superficially in order to produce counter-irritation.

Removal of hypertrophied or diseased intra-nasal structures is effected by means of nasal snares, scissors, or punch forceps.

Snares may be divided into two main classes:

(1) Those in which the barrel is open at the distal end, so that the wire loop can be drawn right into it.
(2) *Those in which the distal end of the barrel is crossed by a bar*, or "stop," which prevents the loop from being drawn inside.

If the former type be employed, the wire loop will cut through any tissue which it encircles at the point of constriction; it is therefore unsuitable for the removal of polypi, as portions of the pedicles will certainly be left behind, and will lead to rapid recurrence. The second type, on the other hand, will not cut through in this manner, and if used for the snaring of polypi will generally tear away the pedicle at its site of attachment, in some cases accompanied by a flake of rarefied bone from the ethmoid itself. Before using a nasal snare one must make sure that the wire loop is not too long to be pulled home; otherwise the snare will slip when traction is applied, and will fail to remove the portion of tissue which has been encircled. The many advantages of the Glegg snare have already been mentioned in a previous chapter. Nasal scissors are useful for trimming the edges of the inferior turbinals, and for dividing the neck of the middle turbinal prior to its removal with a snare. The blades should be at an angle to the shafts, and they must cut sharply right to the very points. Punch forceps have been devised by the score, and each operator will discover his favourite type by a process of elimination; it is advisable to "try out" those in the instrument cupboard of a hospital before laying in one's own stock. Such forceps are useful in removing polypi or portions of turbinals, and are especially valuable where a good deal of trimming-up has to be done.

Partial Turbinectomy.

It is sometimes necessary to remove the hypertrophied anterior or posterior end of the inferior turbinal, and occasionally amputation of both ends may be required. The parts which are removable with a snare are indicated in figure 2548, which is a modified form of the diagram appearing in Lamb's *Diseases of the Throat, Nose and Ear.*

A. Inferior Turbinals

Anterior Turbinectomy.

This is performed by means of scissors and snare after local anæsthesia has been induced. The blades of a pair of strong nasal scissors are introduced, one above and the other below the turbinal head, and a cut is made through the bone and soft parts at the attachment of the inferior turbinal to the outer nasal wall. This incision extends for about

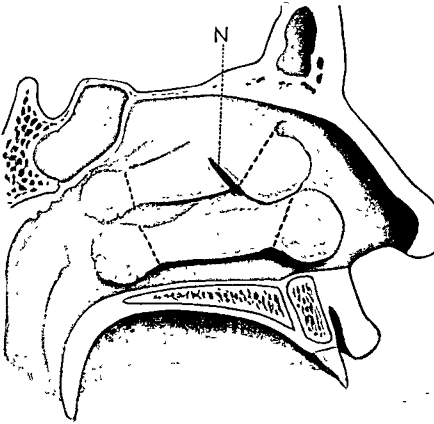


Fig 2548.—Diagram showing portions of turbinals which may be removed with a snare. The dotted lines represent the sites of removal of the anterior and posterior hypertrophies of the turbinals. N. Notch cut with forceps to prevent loop from slipping during removal of anterior end of middle turbinal.

three-quarters of an inch, and the portion of the turbinal thus divided is then pressed inwards by means of a flat elevator. The wire loop of a snare is next introduced and pushed to the posterior extremity of the incision; as the loop is closed to cut through the turbinal head, the tip of the barrel must be pushed backwards so that the whole of the semi-divided portion is included within the loop. It is of the utmost importance that the "grip" of the loop should not slip during this manœuvre.

Amputation of the head of the inferior turbinal is usually per-

Removal of the Anterior End of the Middle Turbinal.

This may be effected with the snare alone, or the combined use of the snare and some form of cutting forceps may be found necessary.

If the hypertrophied anterior end is large and bulbous, and projects downwards and forwards at a well-marked angle, the snare will usually grasp it securely and remove it effectively. If, however, the enlargement is mainly a bony one, and if the angle is not well-marked, the wire

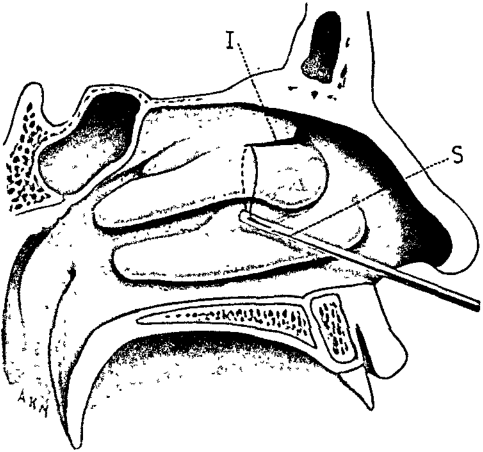


Fig. 2551.—DIAGRAM SHOWING REMOVAL OF ANTERIOR END OF MIDDLE TURBINAL WHERE NARROWNESS OF NOSE DOES NOT ALLOW OF INSERTION OF FORCEPS TO CUT A NOTCH AS IN *Fig.* 2550.

I. Incision made by scissors.
S. Snare inserted with loop along incision, with barrel of snare beneath lower border of middle turbinal.

loop tends to slip off, and to remove only a tag of the overlying mucosa. In these circumstances it is advisable to cut a deep notch, as indicated in figure 2550, by means of Grunwald forceps, and then to apply the loop of the snare. As the loop is tightened the distal end of the barrel must be pressed firmly upwards to obtain a secure grip. If, owing to the extreme narrowness of the nasal cavity, the blades of the forceps cannot be opened widely enough to cut the notch, the attachment of the turbinal to the outer nasal wall may be divided with angled scissors.

B. Middle Turbinals

Hypertrophies of the middle turbinal are almost invariably associated with some degree of ethmoidal disease, a point which must be borne in mind when operative treatment is contemplated.

Enlargement of the Anterior End.

This is nearly always due to a chronic ethmoidal osteitis, which causes a gradual enlargement of the anterior third of the middle turbinal.

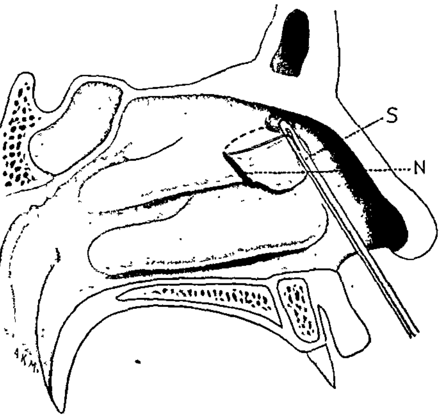


Fig. 2550.—Diagram showing removal by snare of anterior end of middle turbinal.
S. Snare applied to anterior end of middle turbinal.
N. Notch cut with Grunwald forceps to prevent loop of snare from slipping off turbinal end.

This enlarged end frequently becomes red and bulbous, and may cause unpleasant neuralgic symptoms by reason of its pressure upon the septum. In certain cases the enlargement is cystic in nature, and due to the excessive development of an accessory cell in the head of the middle turbinal. Again, the middle turbinal may be apparently double owing to a marked swelling of the unciform process. The cleft which separates this latter from the middle turbinal gives rise to the bifid appearance.

CHAPTER VI

Nasal Polypi

Although the nasal polypus was for many years considered to be a benign form of new growth, it is now generally recognised to be closely associated with ethmoidal disease. Woakes first pointed out that a *polypus in the nose is merely a symptom of underlying bony disease*, and Lack later placed our conception of the condition upon a sound pathological basis.

The number and nature of the polypi give a valuable clinical indication as to the amount of associated bony disease which is present, and visual examination of the nasal cavities will often provide useful information both as to the prognosis and to the extent of operative interference which will be required. The presence of merely one or two pedunculated polypi shows that in all probability the osteitis is localised or even arrested; if, on the other hand, crops of small sessile polypi are seen, and if there is marked œdema of the mucosa, it can be safely assumed that the bony disease is active and widespread.

Incidence and Appearance.

Polypi are most often met with during the third and fourth decades, and are usually said to be very rare before the age of ten years. It seems, however, that this rarity is now disappearing to some extent, and the writer has upon several occasions removed ordinary nasal polypi from children aged eight years and under.

Polypi vary considerably in size and number, but they usually give the appearance of greyish, gelatinous, oyster-like masses, especially when they are of the pedunculated variety. If, however, they protrude into the vestibule or the nasopharynx their surface tends to become red and roughened, and their appearance strongly suggests that of a papilloma. A point of great diagnostic importance is that *they almost invariably originate from the ethmoidal region under cover of the middle turbinal.*

Symptoms.

The main symptoms are those of nasal obstruction, and many patients complain that their symptoms are barometrical in nature, and vary according to the state of the weather. Pressure of the polypi against the septum may produce severe neuralgia, especially across the bridge of the nose and in the supra- and infra-orbital regions, whilst aprosexia and anosmia are not infrequent symptoms. Sneezing, hay-

The loop of the snare is passed along this incision, with the barrel beneath the lower border of the turbinal, and firm pressure is maintained in a backward direction while the loop is gradually tightened (see fig. 2551). In those cases where it is extremely difficult to apply the snare, it may prove necessary to perform a piecemeal removal of the turbinal with punch forceps.

The removal of a cystic enlargement may be accomplished in some cases by means of the snare, but this method is liable to leave behind portions of the cyst wall, and these remnants must then be " mopped-up " with punch forceps.

they must be diagnosed from posterior turbinal hyperplasias and *adenoids, or from fibromata, endotheliomata, sarcomata and epitheliomata* of the naso-pharynx. A good skiagram may show some involvement of the mucous membrane of the antrum, but, paradoxically enough, the affected antrum may trans-illuminate more brightly than the sound one.

X-ray photographs are also of great value when multiple polypi are present, as they will demonstrate the presence of any associated disease of the accessory sinuses, and the extent of the coexistent ethmoiditis.

Prognosis.

Prognosis is extremely difficult in many cases. If left untreated, polypi tend to increase in size and number, and may in time lead to marked impairment of the general health, or even to serious complications. On the other hand, polypi have a notorious tendency to recur repeatedly after local removal, for such removal obviously fails to eradicate the source of the disease. It is apparent that topical applications can have no curative effect in the presence of bony disease, and some form of operative treatment is therefore necessary. In this connection a few prognostic points may here be tabulated:

(1) *A single pedunculated polypus, especially if it is cystic in nature*, does not tend to recur after complete local removal.

(2) Polypi associated with obvious disease of an accessory nasal sinus are amenable to surgical treatment if the patient is prepared to face the appropriate operation.

(3) Even should the patient refuse a radical operation, he may be promised considerable relief from his symptoms if he will submit to *occasional removal of the polypi by means of the snare.*

(4) In the case of the choanal polypus its removal is usually curative in effect, as any bony disease which may have been present has almost invariably been arrested before the polypus is discovered.

Treatment.

The treatment of nasal polypi will naturally depend upon the quiescence or activity of the underlying bone disease. In the former case, simple removal with a snare will usually suffice; in the latter, simple removal can be looked upon as merely a palliative measure; to effect a cure more radical measures must be undertaken, and the underlying diseased bone must also be taken away.

Simple Removal.

For this operation it is essential to have:

(1) Good anæsthesia.
(2) Good illumination.
(3) A good snare.

fever and asthma are often aggravated, if not caused, by the presence of polypi, and a harsh, purposeless cough is frequently a part of the train of symptoms. The patient occasionally complains that he feels as if he has " a valve in the nose," or he may state that a lump sometimes protrudes from the front of the nose. A certain degree of deafness or giddiness may be produced. and some authorities believe that polypi may be one of the causes of epilepsy. Frequently the voice takes on a nasal intonation, and there is commonly a profuse nasal discharge, which may vary from a watery to a thick purulent consistency.

In extreme cases the polypi attain an enormous size, and may then produce distension and external deformity of the nose.

Diagnosis.

This is usually not difficult if a careful examination is made after cocainisation, but every rhinologist knows to his cost that many so-called polypi sent to him for treatment are in reality turgescent or hypertrophied turbinals or middle turbinal cysts. The difficulty then arises of reconciling the practitioner's diagnosis with that of the rhinologist. If it is borne constantly in mind that polypi originate from the ethmoid especially under cover of the middle turbinal, such mistakes in diagnosis should not occur; in the case of turbinal turgescence the application of cocaine will cause very marked reduction of the swelling. Moreover, turbinal turgescence and hypertrophy frequently originate in the inferior meatus.

Tuberculous and syphilitic manifestations have also been mistaken for polypi, but except for the fleshy syphilitic granulomata the appearances are not sufficiently similar to cause confusion.

From malignant ethmoidal disease the diagnosis may be extremely difficult; these growths are frequently overlaid by multiple polypi, and the true condition becomes apparent only after the latter have been removed. Frequent attacks of spontaneous epistaxis in the presence of polypi should arouse suspicion of malignant disease.

The choanal, or post-nasal, polyp may here be mentioned. This polypus is peculiar in that it is usually unaccompanied by bony disease, and is almost invariably single. It generally springs from the posterior part of the middle turbinal, or from just within the maxillary antrum. In the latter case it is attached to the antral mucous membrane by a long narrow pedicle, which passes through the antral ostium. Choanal polypi may attain a great size, in which case they sometimes hang down well into the oro-pharynx, and may be seen on inspection through the mouth; usually they are of moderate dimensions, and their presence is detected only by the use of a post-nasal mirror. In the latter case

circumstances should the nose be tightly packed with gauze, or severe sepsis may supervene. For the next few days a few drops of hydrogen peroxide may be trickled into the nostril at frequent intervals, while later on a mild alkaline nasal wash may be used.

A most important part of the after-treatment is the regular inspection of the nose for the appearance of recurrences, and their prompt treatment.

With patience and perseverance, on the part of both patient and surgeon, even bad cases of nasal polypi may thus be cured; but, if after several careful snarings the recurrences persist, a more radical procedure must be adopted.

Removal of a Choanal Polypus.

If the polypus is of medium size, and does not protrude far back into the post-nasal space, it may be snared under local anæsthesia. Where the polypus is rather larger, a general anæsthetic must be administered, and the left forefinger passed into the naso-pharynx to guide the loop over the end of the polypus. In such cases the superiority of a Glegg snare will again be apparent, for a large loop may first be passed over the bulky free end of the polyp, and then be easily adjusted so as to grip the pedicle firmly. Another method is to introduce a long pair of polypus forceps along the nasal floor, and to guide the pedicle between the open blades of the forceps with the forefinger in the naso-pharynx. The polypus is thus firmly grasped by the blades, and by a twisting and pulling movement is torn from its attachment and removed through the nose. Occasionally the polypus is too large to allow of its removal through the nose; in such cases it is necessary to introduce a pair of curved forceps into the naso-pharynx via the mouth, guide the ends with the forefinger, grasp the pedicle securely, and tear it from its attachment.

Removal of Polypi with underlying Bone.

The methods to be adopted here vary according to whether the associated bony disease is limited or widespread in extent. In either case it is of the utmost importance to remove not only the polypi but also the whole of the diseased bone.

In localised cases the method closely resembles that for removing simple polypi, but an attempt must be made to include the bone as well as the polypi in the loop of the snare. This is especially indicated where the head of the middle turbinal is the chief seat of the disease. Where the uncinate process or ethmoidal bulla are mainly involved these must be cleared with cutting forceps or curettes; it will usually be necessary to amputate the head of the middle turbinal in order to obtain adequate access to these structures.

Local anæsthesia suffices, and is induced as already described. The importance of good illumination is obvious, since one has to work in a narrow and confined space. The writer's predilection for the Glegg type of snare has been previously stressed.

The wire loop is passed back vertically in the nose, the lower border being kept in contact with the nasal floor, until its distal end is well behind the polypus; the loop is then gently slipped round the lower end of the polypus, and with a slight side-to-side and upward movement is insinuated under cover of the middle turbinal as near as possible to the attachment of the polypus. The noose is then tightened, and the polypus pulled sharply away from its attachment. As a rule, the whole of the pedicle will come away, often accompanied by a small scale of the subjacent bone (fig 2552). In some cases, where the polypi spring from

Fig. 2552.—Drawing of a nasal polypus removed with a Glegg snare.

A Flake of ethmoid bone.

B. Constriction where polypus was grasped by loop of snare.

the anterior end of the *middle turbinal*, the latter may be removed together with the polypi; such removal is advantageous as it diminishes the likelihood of recurrence. Should bleeding obscure the view, it is well to press on the spot with a mop of cotton wool wrung out of hydrogen peroxide, which is for this purpose a better and safer styptic than adrenalin.

If both sides of the nose are affected, an attempt must be made to clear one side as completely as possible in order to restore some degree of nasal respiration; the treatment of the second side may well be deferred for seven to ten days.

After the snaring of polypi, brisk hæmorrhage may ensue, but this can usually be controlled by the application of iced compresses to the bridge of the nose. In stubborn cases it may be necessary to use hydrogen peroxide on cotton wool, and to pack it in the nose for ten minutes or so. A loose pledget of wool may then be inserted in the vestibule to prevent blood from trickling over the upper lip. In no

the hæmorrhage stops quickly on the application of iced water to the nose, but occasionally the nasal cavities must be temporarily packed with gauze. Except as a last resort, prolonged packing of the nose is unjustifiable, as sepsis is already present, and serious complications may result.

Although widespread recurrences are rare after the performance of Lack's operation, the patient must be kept under observation, and any small recurrences dealt with by the snare or forceps under cocaine anæsthesia. If suppuration persists, it indicates the presence of accessory nasal sinus disease, and must be treated by appropriate surgical measures.

Difficulties which may confront the Operator.

In a small percentage of cases the removal of nasal polypi appears to cause a violent reaction in the ethmoidal region, and, when next seen, the patient has produced a copious crop of œdematous polypi. In these circumstances it is advisable to hold one's hand, and to wait for the congestion to subside before attempting to remove these fresh polypi. If this is done, a much longer period of immunity from recurrence will follow the second operation. The liability of some patients to suffer from mental changes after repeated operations under cocaine anæsthesia has already been mentioned.

The major difficulties encountered during the operation are usually caused by the presence of septal spurs or deviations. Such obstructions may not be recognised until the anterior polypi have been removed, and it is in these cases that efficient illumination and cocainisation are of the utmost value. In many cases of marked septal deflection it may be necessary, or at least advisable, to perform a submucous resection before attempting to deal with the polypi.

If the hæmorrhage is so severe as to obscure the operator's view, it is better to have sufficient strength of mind to desist for the time being, and to postpone the completion of the operation to a later date. Blind manipulation will lead only to incomplete removal of the polypi, and to the production of troublesome adhesions. Adrenalin should not be used for the arrest of hæmorrhage when the patient is under a general anæsthetic, as symptoms of collapse are liable to follow its application to the bleeding area; in no circumstances must solutions of adrenalin be injected submucously when chloroform anæsthesia is being administered, as several cases of sudden death have occurred under such conditions.

The most stringent precautions must be taken against the possibility of injuring the cribriform plate during the operation, as the danger of meningitis resulting from such an accident is a very real one.

Other less serious complications may occur: some degree of septic absorption accompanied by pyrexia frequently follows the operation, acute otitis media may ensue, and, later on, adhesions will appear, especially in narrow noses. Occasionally, the orbital plate of the ethmoid is damaged, and blood may be extravasated into the orbit, with consequent blackening of the lower or upper eyelid. Less frequently, air finds its way into the orbit, and in such cases the patient must be warned not to blow his nose for the next few days.

When the bony disease is extensive, more radical measures must be undertaken, and the method advocated by Lack is most valuable. This is indicated in cases of extensive ethmoidal disease accompanied by the presence of multiple polypi and by a considerable degree of suppuration; also in those instances where simpler measures have repeatedly failed to effect a cure. The question of the appropriate anæsthetic is an important one: general anæsthesia is usually induced, but many operators consider the local anæsthesia produced by Sluder's method to be sufficient. If the anæsthetic is intra-tracheal, the pharynx may be thoroughly packed off with gauze to prevent the passage of blood into the œsophagus or the lower air-passages. The patient is placed on the operating table with the head slightly raised and turned well to one side: a strong light is thrown into the nose, and a rapid clearance of the polypi is made with a Watson-Williams polypus forceps. A digital examination of the nasal cavities and post-nasal space is then made to determine the amount of bony disease and the presence of any remaining polypi If posterior polypi are present, they may be guided into the jaws of the polypus forceps by the forefinger in the naso-pharynx. The middle turbinal should next be removed with Grunwald forceps or a spoke-shave, after which a large Meyer ring-knife is introduced, and passed upwards and backwards into the nose, with the cutting surface facing outwards towards the orbit. The lateral mass of the ethmoid is now rapidly scraped away until healthy bone is reached, such bone being firm and offering marked resistance to the ring-knife. It is of the utmost importance to avoid injury to the cribriform plate, and all these manipulations should therefore be performed below the level of attachment of the middle turbinal, whilst the ring-knife must be kept facing outwards, and be drawn from behind forwards and slightly downwards.

The special operations devised for the exenteration of the ethmoidal labyrinth will be discussed in a later chapter.

The radical operation is contra-indicated in elderly and debilitated patients, in whom an attempt must be made to relieve the condition by a series of repeated minor procedures. In some such cases, however, the repetition of operations under cocaine anæsthesia appears to produce a condition of severe mental depression, and all active measures may have to be suspended.

After-Treatment.

After any nasal operation which involves the removal of bone, bleeding is very profuse, and when the operation has been completed the patient must be immediately turned over so that the mouth and nose face downwards. As a rule,

Opening of spenoidal sinus.
Supreme turbinal.
Suprameatal recess — Openings of posterior ethmoidal cells.
Superior turbinal.
Openings of posterior ethmoidal cells.
Middle turbinal.
Openings of anterior ethmoidal cells (bullar group).
Ethmoidal bulla.
Frontal recess.
Opening of fronto-nasal duct.
Semilunar groove.
Semilunar gap.
Openings of anterior ethmoidal cells (fronto-nasal group).
Uncinate process.
Usual opening of maxillary sinus.
Accessory opening of maxillary sinus.
Inferior turbinal.
Opening of naso-lachrymal duct.

It will be noted that Layton here uses the terms semilunar groove and semilunar gap in place of the old terms hiatus semilunaris and infundibulum.

Classification of Accessory Sinuses.

Maxillary sinus.
Frontal sinus with its fronto-nasal duct.
Anterior ethmoidal cells:

Fronto-nasal group
- Agger type.
- Uncinate type.

Bullar group
- The bulla cell.
- Orbito-ethmoidal cells.

Posterior ethmoidal cells.
Sphenoidal sinus.

The "key" bone of the nose is undoubtedly the ethmoid, which is composed of numerous cells, and is wedged in the floor of the anterior fossa of the skull immediately in front of the body of the sphenoid, and between the two halves of the frontal bone. *The ethmoid consists of two lateral masses united in the middle* line by the perpendicular plate of the ethmoid, which is a component part of the bony nasal septum. The lateral masses are connected by the cribriform plate, a narrow strip of bone which contains numerous perforations for the branches of the olfactory nerve. The cribriform plate is of paramount surgical importance, as through it there is direct communication between the nasal and the anterior cranial fossæ, and all operative procedures upon the ethmoidal cells must be performed lateral to this area. The ethmoid has also a very close relationship to the orbital cavity on each side; the inner part of the orbital plate of the frontal bone closes in some of the ethmoidal cells, whilst the outer wall of the lateral mass of the ethmoid forms the greater portion of the inner wall of the orbit, and anteriorly

CHAPTER VII

Diseases of the Accessory Nasal Sinuses

These diseases, and their treatment, tend to occupy the attention of rhinologists to an ever-increasing extent. It is possible that improved methods of clinical and radiological diagnosis have been responsible for the recognition of a greater number of such cases than hitherto, but the probability is that the diseases themselves are becoming increasingly frequent among civilised peoples.

In any event, the study of these infections is of the utmost importance to the specialist and the problems associated with their treatment have probably caused more ink to flow than any other rhinological condition. The controversy has split the ranks of rhinologists into several "camps," each of which contains many fanatics, and a perusal of the copious literature upon the subject tends to bewilder the young nasal surgeon. The truth probably is that each type of case presents its own peculiar problem, in some instances demanding conservative, in others radical, measures; the surgeon must work out his own salvation, and that of the patient, by the light of experience.

Every young rhinologist is strongly advised to read carefully Herbert Tilley's address on "The Nasal Accessory Sinuses," which appears in the *Journal of Laryngology and Otology* December 1932. Here Tilley speaks with all the authority of his rich experience, and presents a lucid and reasoned exposition of the problem. His sane and considered judgment will counteract the optimism with which each new operation is greeted in some quarters.

Anatomical Considerations.

It is essential for the rhinologist to have an accurate knowledge of the anatomy of the nose and paranasal sinuses ere he embarks upon intra-nasal surgery. He will do well to make a careful study of the magnificent Onodi Collection in the Museum of the Royal College of Surgeons of England, and Layton's Catalogue of the Collection should most certainly be in his hands.

Each nasal passage is sub-divided by the three turbinates into four meatuses, which run in an antero posterior direction. In these meatuses are found many important structures and the openings of the paranasal cells and sinuses. These may be represented diagrammatically thus (Layton):

Opening of spenoidal sinus.
Supreme turbinal.
Suprameatal recess — Openings of posterior ethmoidal cells.
Superior turbinal.
Openings of posterior ethmoidal cells.
Middle turbinal.
Openings of anterior ethmoidal cells (bullar group).
Ethmoidal bulla.
Frontal recess.
Opening of fronto-nasal duct.
Semilunar groove.
Semilunar gap.
Openings of anterior ethmoidal cells (fronto-nasal group).
Uncinate process.
Usual opening of maxillary sinus.
Accessory opening of maxillary sinus.
Inferior turbinal.
Opening of naso-lachrymal duct.

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Classification of Accessory Sinuses.

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Frontal sinus with its fronto-nasal duct.
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- Agger type.
- Uncinate type.

Bullar group
- The bulla cell.
- Orbito-ethmoidal cells.

Posterior ethmoidal cells.
Sphenoidal sinus.

The "key" bone of the nose is undoubtedly the ethmoid, which is composed of numerous cells, and is wedged in the floor of the anterior fossa of the skull immediately in front of the body of the sphenoid, and between the two halves of the frontal bone. The ethmoid consists of two lateral masses united in the middle line by the *perpendicular plate of the ethmoid, which is a component part of the* bony nasal septum. The lateral masses are connected by the cribriform plate, a narrow strip of bone which contains numerous perforations for the branches of the olfactory nerve. The cribriform plate is of paramount surgical importance, as through it there is direct communication between the nasal and the anterior cranial fossæ, and all operative procedures upon the ethmoidal cells must be performed lateral to this area. The ethmoid has also a very close relationship to the orbital cavity on each side; the inner part of the orbital plate of the frontal bone closes in some of the ethmoidal cells, whilst the outer wall of the lateral mass of the ethmoid forms the greater portion of the inner wall of the orbit, and anteriorly

comes into contact with the posterior half of the lachrymal bone, which forms the outer wall of some of the anterior ethmoidal cells. The superior and middle turbinals are an integral part of the ethmoid, and lateral to the middle turbinal are several important structures on the outer wall of the nose. These have been enumerated in the table given on page 4735; one of the most important is the uncinate process, a ridge of bone which runs downwards and backwards from the anterior part of the lateral mass, twisting as it does so, in some cases to such an extent that it becomes almost horizontal. Above the uncinate process is seen the bulla ethmoidalis, which is a projection caused by an enlarged ethmoidal cell and can sometimes be seen on examination through the nasal speculum. Between the bulla and the uncinate process lie the semilunar groove and gap, into which many

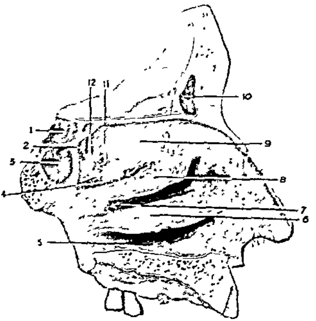


Fig. 2553.—Lateral wall of left nasal cavity, showing the conchæ or turbinated bodies, the meatuses, and the spheno-ethmoidal recess.

1. Right sphenoidal sinus.
2. Sphenoidal ostium.
3. Left sphenoidal sinus.
4. Superior meatus.
5. Inferior meatus.
6. Inferior concha.
7. Accessory ostium of maxillary sinus.
8. Middle concha.
9. Superior concha.
10. Frontal sinus.
11. Ostium of posterior ethmoidal cells.
12. Spheno-ethmoidal recess.

(From Logan Turner's "Diseases of the Ear, Nose and Throat," Wright, Bristol. By kind permission.)

of the accessory nasal sinuses open. It should be remembered that the normal opening of the maxillary sinus is to be found here and is therefore badly situated for natural drainage (figs. 2553, 2554 and 2555).

Special mention must be made of the agger nasi cell, which is a prominence due to one or more of the anterior ethmoidal cells, and is situated just in front of the anterior margin of the middle turbinal. Mosher has called attention to the special importance of this cell because of the bearing it may have upon the causation and treatment of infection of the paranasal sinuses, more especially of the frontal sinus. If well developed, or swollen by disease, it may bulge into the fronto-nasal duct, and thus interfere with the natural drainage of the frontal sinus, and render difficult, or even impossible, the passage of instruments along the duct. In operating on the frontal sinus it is therefore essential to deal adequately with this cell.

It has already been noted that the ostium of the maxillary sinus is badly situated for natural drainage, and it may be well to consider the relative positions of the other ostia to the cavities which they serve. The opening of the frontal

sinus is at the most dependent part, but the openings of the other cavities vary considerably, and are seldom found to be at or near the lowest part. The posterior ethmoidal cells usually open independently, but occasionally some of them communicate with the sphenoidal sinus, the proper ostium of which is almost invariably

Fig. 2554.—Coronal section through the nasal cavities and maxillary sinuses on the plane of the ostia of the sinuses (viewed from behind)

1. Left frontal sinus.
2. Left anterior ethmoidal cell.
3. Olfactory sulcus.
4. Right anterior ethmoidal cells.
5. Right frontal sinus.
6. Ethmoidal bulla.
7. Semilunar gap (hiatus semilunaris).
8. Semilunar groove (infundibulum).
9. Uncinate process.
10. Middle conchal cell.
11. Middle meatus.
12. Inferior concha.
13. Maxillary sinus.
14. Inferior meatus.

(*Logan Turner.*)

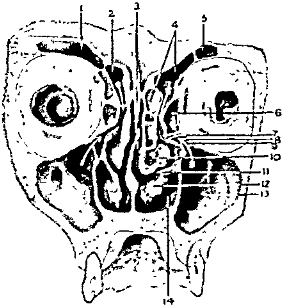
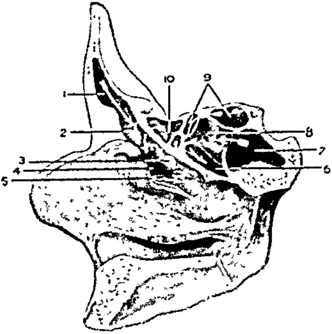


Fig. 2555.—Lateral wall of the right nasal cavity with the superior and the middle conchæ removed. The semilunar groove and naso-frontal duct are continuous. The uncinate process has been turned down in order to show the maxillary sinus ostium.

1. Right frontal sinus.
2. Naso-frontal duct.
3. Ethmoidal bulla.
4. Semilunar groove (infundibulum).
5. Ostium of maxillary sinus.
6. Superior meatus.
7. Right sphenoidal sinus.
8. Spheno-ethmoidal recess.
9. Posterior ethmoidal cells.
10. Anterior ethmoidal cell.

(*Logan Turner.*)



situated high up in the anterior wall. It should be borne in mind that when the opening of a cavity is at its upper part the drainage depends wholly upon the action of the ciliated epithelium lining the cavity. The cilia work towards the ostium, and if they are damaged or destroyed by suppuration within the cavity the process of natural drainage is markedly inhibited.

A. Acute Inflammatory Affections of the Accessory Nasal Sinuses

These are characterised by an acute inflammation of the mucous membranes lining the paranasal sinuses, and this leads to the pouring out of an abundant secretion. The secretion is at first mucoid in character, but may later become muco-purulent or frankly purulent, and may then undergo retention in the affected sinus.

Acute sinusitis is almost invariably an extension of an acute rhinitis, and is especially liable to occur during the course of acute specific fevers, particularly influenza. It is also obvious that an exacerbation of a chronic sinusitis will frequently give rise to an attack of the acute variety.

Another source of infection, which of late years has been held responsible for many cases of acute sinusitis, is the water in the swimming-baths which now abound throughout the country; the increased incidence of these infections during the summer months has certainly been most striking

Amongst other causes may be mentioned injuries to the sinuses, atrophic rhinitis, tubercle, syphilis (now much rarer than formerly), the presence of a foreign body in a sinus, and infection following intra-nasal operations, especially in those cases where prolonged nasal packing has been necessary.

In the case of infections of the maxillary antrum one of the most important predisposing causes is dental or peri-odontal suppuration.

It should be remembered that one sinus may be acutely infected by pus which passes into it from another sinus.

Pathology.

The primary pathological changes are merely those which occur in acute rhinitis; in fact, acute sinusitis is simply an extension of the rhinitis to the mucosal lining of the sinuses. The mucous membrane becomes œdematous, and throws out excessive secretion; subsequent changes depend to a considerable extent upon whether the ostium of the sinus becomes so obstructed as to prevent natural drainage. If the infection is very severe, the ciliary action may be paralysed, and drainage may thus be further interfered with.

If retention occurs, the mucous membrane over the middle turbinal and the outer nasal wall may become markedly œdematous, or there may be bulging of the walls of the antrum, or of the ethmoidal cells, into the nasal cavity.

Acute infections of the frontal sinus or the ethmoid may give rise to external redness and œdema, but these signs are seldom present

where the maxillary sinus is involved. Should external redness and swelling of the cheek be present, a dental rather than an antral suppuration may be suspected.

Symptoms.

These are similar to those of a severe "cold in the head," but the occurrence of a rigor at the onset raises the suspicion of the involvement of the sinuses.

Acute catarrhal inflammation of the frontal sinus or of the anterior ethmoidal cells causes a dull supra-orbital headache, a feeling of heaviness in the head, and tenderness on palpation beneath the supra-orbital ridge. Neuralgia of the cheek and the teeth is frequently complained of when the maxillary antrum is acutely inflamed.

Once the ostium of a sinus becomes blocked the symptoms increase in intensity. Nasal obstruction is very marked, the nose may feel distended as if it is about to burst, headache is intense, and superficial tenderness over the affected sinus is greatly increased. When the sphenoidal sinus is the seat of acute infection the headache may be so severe as to simulate the onset of meningitis. Sphenoidal headache is usually referred to the occipital region, and tenderness over the mastoid process is commonly present.

If "closed" sinus suppuration occurs, there is further exacerbation of the symptoms, associated in some cases with the appearance of redness, swelling, or even a superficial abscess over the affected sinus.

Unless appropriate treatment is adopted. the symptoms persist until the fluid, muco-purulent or purulent, finally makes its escape through the natural opening. When, however, the fluid fails to escape by this means, an abscess of the sinus may result, which may either burst through its bony wall, or cause other serious complications. Many cases have been reported of orbital cellulitis and abscess, spreading osteomyelitis of the frontal bone, septicæmia, and such intra-cranial complications as meningitis, extra-dural and cerebral abscesses, and infective thrombosis of the cavernous sinus.

Fortunately, however, acute sinusitis tends to resolve completely if appropriate treatment be given; but it must be remembered that repeated attacks of acute sinusitis are the most potent ætiological factor in the causation of chronic infection of the sinuses.

Diagnosis.

The occurrence of severe headache, or of facial neuralgia, in the presence of an acute rhinitis should suggest involvement of the sinuses, and the probability is increased if a unilateral nasal discharge be present. In many cases, however, the patient is confined to bed, and the discharge

then tends to flow backwards into the naso-pharynx. A careful examination of the nose and post-nasal space, assisted by trans-illumination of the sinuses, will usually lead to the making of a correct diagnosis. If the patient is seen only in the later stages, when serious complications have already appeared. the presence of the primary sinusitis is apt to be overlooked.

Treatment

The ordinary therapeutic measures applicable to the treatment of acute rhinitis must be promptly adopted. but it is also necessary to attempt to promote drainage of the sinuses. A nasal spray of cocaine and adrenalin. and inhalations of the vapour of menthol in Friar's balsam. have proved most beneficial in relieving the pain and encouraging the escape of secretions from the sinuses. Nasal douches are at once useless and dangerous but I have obtained excellent results from packing the nasal cavities with pledgets of cotton wool soaked in 20 per cent argyrol. One such pledget is inserted as far as possible into each of the three meatuses on each side of the nose. and allowed to remain in position for twenty minutes. Their removal is followed by a copious flow of secretion. which may be evacuated from the nose by gentle blowing. or by the use of a suitable suction apparatus.

Applications of dry or moist heat to the forehead and nasal bridge have also proved of great value. and special radiant heat baths give magical relief in certain cases.

These measures are especially effective in the treatment of acute frontal sinusitis. and the pendulum has at present definitely swung towards the "conservative" treatment of this condition. At a recent meeting of the Laryngological Section of the Royal Society of Medicine it was most noticeable that the "lions" lay down with the "lambs," and with one voice condemned active surgical interference in acute frontal sinusitis unless serious complications threatened or were present.

If. however. the above treatment fails to give complete relief, and suppuration persists. it will be necessary to wash out the sinus either through its natural ostium or through an artificial opening. Lavage of the maxillary sinus through its natural opening is difficult and uncertain, and although this procedure has been recommended in several text-books I have never yet managed to carry it out with success. On the other hand, the puncture of the outer antral wall beneath the inferior turbinal is a comparatively simple operation, which causes little discomfort to either patient or surgeon!

The writer invariably uses a straight Lichwitz trocar and cannula, but many surgeons prefer a curved model such as that of Myles.

Exploratory Puncture and Lavage of the Antrum.

Local anæsthesia is first established by pushing under the inferior turbinal a carrier, round the end of which has been twisted a wisp of cotton wool impregnated with a 10 per cent solution of cocaine and adrenalin. This is left for ten minutes in contact with the outer nasal wall just below the attachment of the inferior turbinal. The carrier is withdrawn, a nasal speculum inserted into the nostril, and, under good illumination, the trocar and cannula is passed into the nose. The sharp end of the trocar is next pushed up under cover of the inferior turbinal until it reaches the outer nasal wall immediately below the turbinal attachment, about ½-inch from its anterior end. The handle of the instrument is then carried towards the opposite nostril so that its point is directed upwards, outwards and backwards, in a line with the outer angle of the orbit. The speculum is now removed, the patient's head steadied with the operator's left hand, and the trocar firmly and quickly pushed through the antral wall. In the majority of cases the bone in this situation is thin and easily perforated, but if the *point of the trocar is placed too far below the turbinal attachment* it may be impossible to penetrate the thicker bone which is here encountered. Should this occur, the point must be slightly with-*drawn and reapplied just below the attachment of the turbinal.* It is essential that the patient's head be kept erect during this procedure.

The antral wall having been punctured, the trocar is withdrawn, and in some cases pus may at once flow out through the cannula. Lavage of the cavity is now carried out with the aid of a 20 cc. Record or a Higginson syringe. The advisability of having the cannula of such a bore that an ordinary Record syringe fits snugly into it has already been mentioned. Lavage is continued until the fluid returns clear. During the syringing the patient should bend his head forwards and pant through the mouth; by this means he avoids getting the fluid "*down the wrong way.*" The *syringing must at first be very gentle,* for if the ostium be partly blocked the introduction of more fluid into the cavity will cause severe pain.

During the lavage a careful watch must be kept to ensure that no swelling of the cheek or orbital tissues occurs.

In many cases a single puncture and lavage will clear up an acute infection of the antrum, but it is sometimes necessary to repeat the operation several times at intervals of 24–48 hours. Where such *measures do not effect a cure the antrum must be opened and drained,* as will be described later.

drain the sinus, either through its natural opening or by means of an external operation. After the induction of local anæsthesia a special frontal cannula is inserted gently into the nose, and an attempt made to pass it through the fronto-nasal duct into the sinus. If the cannula be successfully passed, the sinus is then irrigated. Unfortunately, this manœuvre is rarely possible unless the anterior third of the middle turbinal is first removed, and the agger nasi and some of the fronto-nasal cells are scraped away. It is obvious that, in the presence of acute inflammation, such measures may lead to severe toxic absorption from the raw surfaces which are thus opened up; moreover, the resultant reactionary swelling will probably cause worse obstruction than before. Although many surgeons have advocated this form of treatment, it appears to the writer that it is contrary to the cardinal rules of surgery, and there is no doubt that many serious and even fatal complications have followed its performance.

Should superficial abscesses form, it will be necessary to carry out one of the external operations which will be described under the treatment of chronic frontal sinusitis; Howarth's operation, or some modification thereof, has proved of particular value in such cases.

Ethmoidal Cells and Sphenoidal Sinus.

The diagnosis of acute suppuration of these cavities is often difficult, although occipital headache suggests the presence of sphenoidal inflammation. If suppuration in the frontal and maxillary sinuses can be excluded on examination, it is possible to explore the ethmoidal cells with a Hajek hook after removal of the anterior third of the middle turbinal, whilst puncture and lavage of the sphenoidal sinus may be carried out with a suitable trocar and cannula. It is usually necessary to remove the posterior half of the middle turbinal in order to gain the required access for this procedure.

B. Chronic Infections of the Accessory Nasal Sinuses

Here the mucous membranes or even the bony walls of one or more of the accessory nasal sinuses are the seat of a chronic inflammatory process, and a purulent discharge is produced. In this way an "empyema" of the sinus results, and three common varieties of these empyemata have been described:

(1) "*Open*" empyema, where the ostium is patent, and the pus can escape into the nose.

(2) "*Closed*" empyema, where distension occurs owing to blocking of the ostium, and the purulent discharge does not drain into the nasal cavities.

(3) "*Alternating*" empyema, where drainage from the ostium occurs only at intervals, and pus accordingly may or may not be detected in the nose or naso-pharynx.

Chronic sinusitis usually results as the sequel to an acute sinusitis which has failed to resolve completely, particularly if the infection has been of the influenzal type. If the infection has been so severe as to cause destruction of the cilia of the mucosal lining, it is apparent that the supervention of chronic sinusitis is more likely to occur, whilst if bony changes have ensued its onset is almost certain.

The other predisposing causes of acute sinusitis may, of course, lead to the chronic form; and in the case of the maxillary antrum, dental infections are common precursors.

It must be borne in mind that the antrum may be full of pus, yet its mucous membrane be healthy; in such cases it is merely acting as a reservoir for pus which has come from the frontal or ethmoidal regions, and has entered through the antral ostium. Should this pus remain in the antrum for any considerable period it will finally produce secondary inflammatory changes in the mucosa.

Pathological Changes

In the affected sinus the mucous membrane becomes thickened, and, owing to its intimate connection with the periosteum, this leads to periostitis and osteitis of the bony walls. As the disease progresses, the mucosa becomes definitely polypoid and the ciliated cells are replaced by cubical ones. The osteitis usually leads to patches of sclerosis, but caries and necrosis are uncommon except in connection with infections of the ethmoidal and fronto-ethmoidal cells. If, however, they do occur, widespread destruction of the bony walls may ensue, and lead to extension of the disease to the surrounding structures. In the nose itself the signs of chronic rhinitis make an early appearance; later, the middle turbinal becomes enlarged and polypoid, or true polypi occur. Pus may usually be detected in the nose or naso-pharynx, and the position of the pus and polypi give a valuable indication as to which set of sinuses is involved.

Symptoms and Signs.

(1) *General.* The symptoms vary considerably, and the degree of pain and tenderness depends to a great extent upon whether the ostia are patent or blocked.

Nasal obstruction is almost invariably complained of, its severity being largely dependent upon the presence and size of the nasal polypi, and the amount of turbinal swelling. Nasal discharge varies greatly in amount and consistency, and in the case of "closed" empyemata

may be entirely absent; but a persistent unilateral purulent nasal discharge *is strongly suggestive of infection of a sinus.* In roomy noses crusting may occur, and conceal to some extent the existence of the discharge.

Headache is a common feature, and is typically of a periodic nature. The patient usually wakes in the morning with a headache, which may increase in intensity for an hour or so until it is suddenly relieved by the escape of pus from the nose. The situation and intensity of the headache may give a valuable indication as to the particular sinus or set of sinuses involved.

Anosmia is a not infrequent symptom, especially where multiple polypi are present high up in the nose. If the patient's sense of smell is not affected he may be conscious of an offensive odour, or he may suffer from some degree of parosmia. When crusting is present the fœtor may be noticeable by those in close proximity to the patient.

Aprosexia and irritability of temper are occasionally marked features of chronic sinusitis.

(2) *Symptoms pointing to the involvement of one or other set of sinuses.* Infection of the anterior set of sinuses usually leads to the appearance of mucosal swelling and polypi round the anterior third of *the middle turbinal and in the vicinity of the uncinate process.* Discharge may be detected under the middle turbinal or high up in the middle meatus, and such discharge tends to reappear rapidly after being wiped or sucked away.

If, however, the polypoid appearance is confined to the posterior part of the middle turbinal, and if the purulent discharge is to be seen only high up in the olfactory cleft, or (on posterior rhinoscopy) along the upper border of the hinder end of the middle turbinal, it may then be assumed that the posterior set of sinuses is involved. It must be remembered that post-nasal discharge may indicate merely an antral infection of dental origin; in such cases the nasal mucous membrane is but little affected, and the unimpaired ciliary action will tend to sweep any discharge from its ostium into the naso-pharynx.

With regard to headaches, it may be taken as a rough general rule that frontal headaches indicate infection of the anterior set of sinuses, whilst occipital headaches are associated with disease of the posterior set.

(3) *Symptoms which point to the involvement of a particular sinus.* An excellent "schema" of differential diagnosis of sinus disease will be found in Ballenger's text-book, *Diseases of the Nose, Throat and Ear,* but it is too lengthy to be included here.

In infections of the maxillary antrum, neuralgic pain may be complained of in the cheek, the upper teeth, and in the infra- or supra-orbital regions. Its intensity depends on several factors, and particularly upon the amount of retained secretion and the degree of chronicity of the inflammatory process.

Direct tenderness over the antrum is not commonly found; if present, it is usually to be detected in the vicinity of the canine fossa.

Referred pain is more frequently present, and may be elicited at the side of the nose, over the malar bone (particularly just in front of the temporo-mandibular articulation), and in the supra-orbital region.

Discharge may vary considerably in amount, and in the case of dental infections may be discovered only by rhinoscopic examination of the post-nasal space. If the discharge is definitely increased on bending the head forwards and to the opposite side, suppuration of the maxillary antrum is to be suspected.

Frontal Sinus.

Pain is here a frequent symptom, and is often periodic in nature. The presence of frontal pain on awakening, and its relief only after a flow of pus from the nose, are highly suggestive of frontal sinus suppuration. The pain is distributed over the supra-orbital, frontal and vertical regions. It must not be forgotten that similar pain may be produced, in the absence of any infective process, by the pressure of an enlarged middle turbinal against a high septal deflection. Direct tenderness may often be elicited in the angle between the nasal bone and the orbital plate of the frontal, and persistent tenderness in this area is a very valuable diagnostic sign; care, however, must be taken not to apply the pressure over the supra-orbital notch, lest supra-orbital neuritis be mistaken for frontal sinusitis.

Referred tenderness may be present over the side of the nose, the supra-orbital and frontal regions, and the vertex of the skull.

Discharge may be a prominent feature, and is usually more continuous and profuse when the patient is sitting or standing. In cases of "open" frontal empyema the pus tends to reappear almost immediately after it has been wiped away from the middle meatus.

Ethmoidal Labyrinth.

Disease of the ethmoid is nearly always closely associated with frontal sinus suppuration, but occasionally only the agger nasi or the anterior middle turbinal cell may be involved.

Pain is usually not a marked feature unless there is coexistent frontal sinusitis, but there may be a dull aching and a feeling of fulness between the eyes and above the root of the nose.

Multiple polypi arise in the vicinity of the anterior third of the middle turbinal, and œdematous granulations are frequently found over the uncinate process.

Discharge may be profuse, and is often seen exuding between the polypi; it tends to reappear rapidly after being wiped away.

Infection of the posterior cells alone is rare, and in most cases there is coexistent disease of the anterior cells or of the sphenoidal sinus. Onodi and others have shown that in a large proportion of cases *one or more of the posterior ethmoidal cells may open directly into the* sphenoidal sinus.

The symptoms are usually rather obscure, but aprosexia, deep-seated pain behind the eyes, and visual disorders may occur.

Pus may be seen in the olfactory cleft, or in the vault of the naso-pharynx, where it courses over the upper border of the posterior end of the middle turbinal.

Sphenoidal Sinus.

Pain is not invariably present, but not infrequently the patient complains of occipital headache or of retro-ocular pain.

Posterior rhinoscopy may reveal redness and swelling of the mucous membrane high up in the naso-pharyngeal vault, and the presence of crusts on the posterior end of the middle turbinal.

Where an empyema of the sinus exists, pus may be withdrawn after the introduction of a sphenoidal trocar and cannula.

If the sinus becomes acutely distended with pus, severe headache *will result and serious ocular complications may ensue.*

COMPLICATIONS OF PARANASAL SINUSITIS

Complications are numerous, and may be of mild or extremely serious import.

Those due to septic absorption by the blood or lymph stream, or by the passage of the discharge into the alimentary canal or the air-passages, are:

Anæmia and general debility; sub-acute or acute rheumatism; myo-, peri-, or endo-carditis; tonsillitis; recurrent attacks of facial erysipelas; dyspepsia, anorexia, and gastro-enteritis; chronic inflammation of the pharynx, larynx, trachea, and the bronchial tubes, with occasional acute exacerbations; Eustachian and middle ear catarrh, with tinnitus and vertigo; suppurative otitis media; ocular disorders such as retro-bulbar neuritis or iridocyclitis, resulting from prolonged septic absorption.

Secondly, there are numerous complications which result from direct local extension of the disease to the *neighbouring structures.*

Erosion of the bony walls may lead to superficial or deep-seated abscesses, of which a common example is the orbital abscess, whilst suppuration in the frontal sinus or the ethmoidal labyrinth may result in a spreading osteomyelitis of the frontal bone. Such osteomyelitis tends to spread over the vault of the skull, and, owing to the likelihood of the supervention of meningitis, the mortality is extremely high. An excellent and classical account of this condition and of its treatment has been given by Dan McKenzie in the *Journal of Laryngology and Otology*, 1913, xxviii, 6, and 1927, xlii, 293. The incidence of osteomyelitis after operative interference upon the frontal sinus has been alarmingly high, and has undoubtedly been largely responsible for the modern adoption of conservative measures in the treatment of acute frontal sinusitis.

The intra-cranial complications are unfortunately only too common, and are generally of very grave import. The principal ones are:

(1) Cavernous sinus thrombosis. This is usually secondary to sphenoidal suppuration, and is almost invariably fatal. It is characterised by proptosis, conjunctival chemosis, paralysis of the orbital muscles, and fixation of the eyeball.

(2) Extra- or intra-dural abscesses in the frontal lobe. These usually arise as a result of erosion through the posterior wall of the frontal sinus, and may be single or multiple.

(3) Meningitis, which is commonly due to ethmoidal infection passing up through the cribriform plate, but which may, as stated above, follow a spreading osteomyelitis of the frontal bone.

Ocular Complications.

In addition to those which have been already mentioned, many other ocular disorders have been described in connection with sinus disease. Thickening of the orbital periosteum, due to direct inflammatory extension from the sphenoid or posterior ethmoidal cells, may be the cause of persistent œdema of the eyelids, and muscular asthenopia and loss of accommodation may result. Other disorders for which sinusitis has been held responsible are conjunctivitis, keratitis, scleritis, choroiditis, iridocyclitis, and retro-bulbar and optic atrophy. Of these complications the most important are those which affect the optic nerve. It is well known that this nerve is peculiarly susceptible to the action of toxins, and the intimate anatomical relationship of the posterior ethmoidal cells and the sphenoid to the optic nerve enables one to realise with what ease infection may pass from these structures to the nerve sheath.

In acute optic or retro-bulbar neuritis there is loss of vision, and

often some difficulty in moving the eyeball. The commonest visual symptoms are dimness of vision, a central scotoma for colours, enlargement of the blind spot, and contraction of the visual field. Examination of the fundus will reveal inflammatory swelling around the optic nerve, and engorgement of the retinal veins.

It should be remembered that operations upon the sphenoid and the posterior ethmoidal region may be followed by partial or complete blindness, and the proximity of these cells to the optic nerve should ever be borne in mind.

Diagnosis.

It is obviously vitally important not only to diagnose the presence of sinus suppuration, but also to determine which cavity is affected.

A careful and detailed consideration of the signs and symptoms detailed already will lead to a correct and accurate diagnosis in the majority of cases; but we have, in addition, two valuable aids to diagnosis in the form of trans-illumination and skiagraphy of the sinuses. The primary importance and value of clinical diagnosis must not, however, be under-estimated.

Trans-illumination in Antral Disease.

This consists in introducing an electric light into the mouth, and comparing the degree of intensity with which it is transmitted through the two sides of the face. The findings are not completely trustworthy, but it may be generally stated that, in the presence of unilateral nasal discharge, diminution of the amount of transmitted light through the affected side is strongly suggestive of the presence of antral suppuration.

Where bilateral infection is suspected, the probability of its presence is strengthened if both sides are dark on trans-illumination, but it must be remembered that some antra will not light up clearly even though exploration may later show them to be quite healthy. Many observers pay little attention to the findings by trans-illumination, and state that antra which contain pus will light up as brightly as normal antra; in no adult case which has come within the writer's limited experience has this statement been confirmed. It is, however, well established that where an antral cyst or a choanal polypus is present the affected antrum may be brighter than its fellow on trans-illumination, whilst a benign or malignant antral tumour will, of course, prevent penetration of the light.

The technique of trans-illumination is as follows:

The patient is taken into a dark-room, any upper dental plate removed, and the lamp introduced into his mouth. It should be held strictly in the mid-line, and pressed against the hard palate. The patient then closes the lips firmly round the lamp, the light is turned on, and the degree of trans-illumination of the two sides is carefully compared. The chief points to be noted are:

(1) The presence or absence of the infra-orbital "crescent" of light.
(2) Whether the light shines through the conjunctiva when the lower lid is turned down.

(3) Whether the light glows through the pupils.
(4) Whether the patient can detect the turning on and off of the light when his eyelids are closed, and whether the sensation of light is equal in both eyes.

When pus is present in the antrum, the cheek on the affected side is almost invariably dark on trans-illumination, but it must not be forgotten that the transmission of the light may be prevented merely by the thickness of the bony wall. Where the mucous membrane of one antrum is swollen, a marked difference in the penetration of the light may be revealed by diminishing its intensity.

Trans-illumination of the frontal sinuses is less trustworthy from a diagnostic point of view, but if both sinuses light up brilliantly the inference is that they are healthy

Trans-illumination of the ethmoids is of less practical value, but some information may be gained by placing the light on the cheek below the inner orbital angle, and noting the intensity with which it penetrates to the hard palate on each side.

The writer would stress the importance of trans-illuminating the antra in all children from whom it is proposed to remove the tonsils and adenoids. Sinusitis in children is undoubtedly more common than is generally supposed, and a considerable proportion of the disappointing results which follow the removal of tonsils and adenoids is certainly due to the presence of an unsuspected sinusitis.

SINUSITIS IN CHILDREN

It will not here be out of place to discuss shortly the problem of sinus infections in children, a subject to the importance of which Coffin first called attention.

The development of the paranasal sinuses in the child shows marked variations both as to size and time of appearance, but, as a general rule, the ethmoidal cells are the only ones which are invariably present at birth. The maxillary antrum is usually present on the nasal aspect of the orbit, but the frontal sinus is represented by a cell in the upper ethmoidal region. The sphenoidal sinus is seldom recognisable at this stage, but becomes so within two to three years after birth. By the time the child attains the age of six or seven years the maxillary antrum has developed in an outward and antero-inferior direction, and the frontal sinus cell has extended upwards into the vertical part of the frontal bone.

In view of the fact that adenoids are so frequently present in early childhood it is not surprising that the chronic catarrhal condition caused by the adenoids invades the membranes which line the sinuses. The consequent blocking of the ostia may then lead to suppuration, particularly after infection during the course of one of the acute specific fevers. The presence of the enlarged adenoid pad inhibits such acts as sniffing and nose-blowing, which are nature's normal means of clearing the nose and sinuses.

The ethmoidal cells are commonly affected, but in the great majority of cases they recover after the adenoids have been removed ; infections of the maxillary antrum are by no means rare, but the sphenoid is seldom involved.

Symptoms.

Nasal obstruction and discharge are almost always present, but it must be remembered that the discharge may be entirely post-nasal, and that in young children the commonest cause of a unilateral nasal discharge is the presence of a foreign body in the nose. Gastro-intestinal disturbances and attacks of pharyngitis and bronchitis are common symptoms, but, as in the case of adults, visual disorders may occur, and any of the grave complications already mentioned may ensue.

Diagnosis.

Many cases of sinusitis in children are unsuspected, but even when one is on the look-out for the condition the diagnosis may be by no means easy. Good skiagrams will give valuable assistance in reaching a correct diagnosis, but in children trans-illumination is less trustworthy than in adults, and it must be confessed that in the former an antrum containing pus may light up quite brightly.

Treatment.

It is obvious that the removal of any adenoids is an important and integral part of the treatment of infections of the sinuses in children. In acute maxillary sinusitis it may be necessary to puncture and wash out the antrum ; in children under the age of four years it may be wiser to puncture above the middle turbinal, as the antral floor is well above that of the nasal cavity.

The surgical treatment of chronic sinusitis will be described later, and these operations may have to be performed upon children. In the latter, however, one is loath to carry out the more radical procedures, whilst intra-nasal operations upon the ethmoid and the frontal sinus should be avoided. In the case of maxillary sinusitis good results are usually obtained after intra-nasal antrostomy, but an operation of the Caldwell-Luc type may be required to effect a cure in some instances.

RADIOLOGICAL DEMONSTRATION OF PARANASAL SINUSITIS

Since Killian first reported the results of X-ray photography of the paranasal sinuses, skiagraphy has played an important role in the diagnosis of disease of the accessory nasal sinuses. In America Caldwell and Coakley developed the technique, whilst in this country Graham Hodgson and others have devised an improved technique which has given excellent results. For many years rhinologists were sceptical, and in many cases perhaps rightly so, of the diagnosis arrived at by X-ray examination ; but this scepticism was due to the fact that the positions

adopted by the radiographer were not always constant, and it is well known that a skiagram taken in an incorrect position will sometimes indicate the presence of disease where, in fact, no such disease exists. Care and practice are required to read correctly an X-ray photograph of the skull from the point of view of disease of the nasal accessory sinuses, for there are several factors to be borne in mind. When taking skiagrams of the skull the surgeon is dealing with one of the most complicated bony structures in the body, and multiple shadows, which differ widely as to size, density, and relative distance from the camera, must be thrown on to the single plane of the X-ray film. As Graham Hodgson writes: "A small difference in the angle of incidence of the rays in the point on the skull over which they are centred, or in the positioning of the patient's skull, will swing the shadows of structures a few inches away from the film through a wide arc, and cause a big variation in their relative positions to structures closer to the film. Hence the absolute necessity for taking the skiagrams at constant and standardised angles for every patient's skull, irrespective of individual differences in shape, for exact centring and angulation of the tube and for taking several views from different standardised angles. In the majority of text-books dealing with the subject only three views are mentioned—a lateral view, and two other views described respectively as the 'nose-chin' and 'nose-forehead' positions. These are not, in fact, 'positions' at all and the multiple shadows in the resulting skiagrams depend for their situations relative to one another on nothing more accurate or scientific than the widely varying facial contours of individual patients. It is hopeless to expect accurate X-ray findings from such inaccurately taken X-ray films."

This was written in 1933, and as a result of the careful and scientific work of Graham Hodgson and other radiologists the position to-day is that skiagrams of disease of the paranasal sinuses provide rhinologists with an accurate diagnosis.

Graham Hodgson makes use of six standard positions, and has designed a special "sinus stand" which ensures exact standardisation of the different positions (fig. 2560) All the views are taken in the erect position, and at definite and accurately measured angles for every patient, irrespective of any difference in facial contour. The erect position is adopted in order to ascertain the presence or absence of a fluid level in the sinuses (figs. 2561–2564).

1. *Occipito-frontal View.*

The head is grasped by the head-clamp in the bi-temporal diameter and the clamp is so adjusted that the antero-posterior diameter of the skull is perpendicular to the film, the angle being read off on the dial. An imaginary line joining the external auditory meatus and the outer canthus of the eye, the "orbito-meatal line," is so adjusted by means of a protractor that it also is perpendicular to the film; the tube is then centred half an inch below the external occipital protuberance and the exposure made. A typical result is shown in figure 2556. The petrous bones will be seen to be thrown well above the antra in this position. The principal use of this view, however, is not to show the antra, but to demonstrate whether there is any abnormal opacity of the ethmoidal labyrinth or of the sphenoidal sinuses. On either side of the perpendicular plate of the ethmoid two air spaces are seen. These air spaces in this position consist of the superimposed shadows of the anterior and posterior ethmoidal cells and the sphenoidal sinuses from before backwards, and normally they are clear.

Fig 2556.—OCCIPITO FRONTAL VIEW.
A. Superimposed shadows of anterior and posterior ethmoid cells and sphenoidal sinuses from before backwards. B. Maxillary antra.

Fig. 2557.—OCCIPITO MENTAL VIEW.
A. Frontal sinuses. *B* Anterior ethmoid cells. C Maxillary antra

Fig 2558.—VERTICO MENTAL VIEW
A *Sphenoidal* sinuses.

Fig. 2559.—LEFT OBLIQUE VIEW
A. Left optic foramen. B. Left posterior ethmoid cells

Fig 2560.—Showing Graham Hodgson "sinus stand" with patient in position for occipito-mental view.

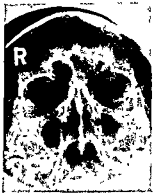


Fig 2561.—Taken in erect position, showing opacity with horizontal upper margin—therefore probably due to fluid.

Fig. 2562.—Same case as shown in *Fig* 2561, but head is tilted to left. Note that horizontal upper margin of opacity still remains horizontal. Nothing but fluid in an air containing cavity can give this appearance.

Fig 2563.—Showing a horizontal fluid level in the right frontal sinus.

Fig. 2564.—Showing a fluid level in both sphenoidal sinuses.

Fig. 2565.—Cystic polypus in left antrum.

(*By kind permission of Dr. Graham Hodgson and the "British Medical Journal."*)

2 *Occipito-mental View.*

In this view the head, still grasped in the bi-temporal diameter, is so adjusted that the orbito-meatal line subtends an angle of 45 degrees to the film, this angle being open towards the feet. In this position (see fig. 2557) the petrous bones are seen to be thrown clear below the antra, thereby giving an unmolested view of these sinuses. The anterior ethmoidal cells are thrown clear of the posterior group of sinuses, and the frontal sinuses are well shown

3 *Vertico-mental View.*

In this position the patient extends the head as far back as possible on the neck. There can obviously be no constant angle through which all patients can extend the head, but this is compensated for by so tilting the tube that, whatever this angle may be, the central ray is constantly vertical to the patient's vertex. This view (see fig 2558) demonstrates well the sphenoidal sinuses.

4. *Right Oblique View*

The head, still grasped in the clamp, is rotated through an angle of 39 degrees, the occiput moving towards the right The chin is then depressed until the orbito-meatal line is at 35 degrees, the tube being centred just behind the left mastoid process. This view throws the shadows of the right posterior ethmoidal cells, and incidentally the right optic foramen, into the shadow of the right orbital cavity.

5 *Left Oblique View*

This corresponds to the preceding view, except that the occiput is here rotated through 39 degrees to the left, thereby showing the left posterior ethmoidal cells (see fig 2559).

6. *Lateral View.*

This is an ordinary lateral view of the sella turcica and the accessory nasal sinuses, and is useful in cases of congenital absence of one or both frontal sinuses, and in cases where one or other antrum is poorly developed, with thick bony walls, and is consequently more or less opaque in the anterior views. The lateral view throws into relief the thick bony walls, and thus clears up the cause of the opacity. Furthermore, in this view the vertical and antero-posterior depths of the frontal sinuses are shown, and the presence of fronto-ethmoidal cells and their relation to the infundibulum are clearly demonstrated. In addition, an exact idea is obtained of the degree of development of the sphenoidal sinus and of the sella turcica.

In certain cases I have found that stereoscopic views have given valuable information where there has been difficulty in clinical diagnosis; in particular, these views give an excellent picture of the ethmoidal labyrinth. A practical point which may prove of value is that by using a magnifying glass to view an ordinary film a semi-stereoscopic effect will be produced.

In recent years many observers, notably A. W. Proetz, have made use of iodised oil and other radio-opaque substances in skiagraphy of paranasal sinus disease. A full description of the method employed may be found in Proetz's *The Displacement Method of Sinus Diagnosis and Treatment.*

Much controversy has arisen as to the advantages or otherwise of this method in skiagraphy of the sinuses. It has attached to itself many perfervid supporters, but others declare that, if the time spent in preparing the patient and instilling lipiodol were occupied in studying a well-taken film with a radiologist skilled in this field of work, an equal amount of information would be obtained in nearly

every case. (W. V. Mullin, *New York State Journal of Medicine*, 1930, XXX, 1280.) R. Graham Brown considers that the results obtained by use of iodised oil and other radio-opaque emulsions are unsatisfactory, and do not compare favourably with those given by the simpler method. The probability is that the procedure may have some additional value in skiagraphy of the sphenoidal sinuses, whilst in such conditions as a septate antrum it will give information unobtainable by simple X-ray examination.

The writer makes no apology for discussing at such length the subject of radiological examination of the paranasal sinuses; with modern methods the results obtainable are an invaluable aid to correct diagnosis, and no operation on the sinuses should be undertaken until skiagrams of the part to be operated upon have been carefully studied by the radiologist and the surgeon.

CHAPTER VIII

Operative Treatment of Chronic Sinusitis

A. Operations upon the Maxillary Antrum

The technique of puncture and lavage of the maxillary antrum has already been described in the chapter upon acute frontal sinusitis.

Puncture through the Alveolar Border was at one time extensively practised, but has now been largely superseded by intra-nasal antrostomy, or by operations of the Caldwell-Luc or Canfield type. It is, however, of some value where the antral suppuration is accompanied by bad dental caries, particularly if the teeth appear to be the probable cause of the infection of the antrum; a short description of the technique will therefore be given:

After removal of the first upper molar (under gas or general anæsthesia) an antral drill is introduced into the socket of the medial fang, and pushed upwards and slightly inwards with a rotatory action until it enters the cavity of the antrum. Care should be taken to prevent the drill entering the cavity with a sudden jerk, lest the floor of the orbit be injured; if the shaft of the drill is steadied with the forefinger of the left hand this accident will be avoided. Should the drill be pointed too far inwards the outer nasal wall may be penetrated. When the antral cavity has been opened it may be irrigated by means of a special cannula attached to a Higginson syringe. In many cases the lavage must be continued daily for some weeks or months, and the patient can, as a rule, quickly learn to do this for himself. To prevent too early closure of the opening, a plug or tube is inserted, and is removed prior to each irrigation. In certain cases the opening may be made through the socket of the second bicuspid or the second molar; in the first instance the drill must face slightly backwards as well as upwards and inwards, in the second a slight forward direction should be given.

Alveolar drainage is particularly suitable for elderly patients, in whom the shock of a more radical operation is undesirable; but in younger patients, where repeated irrigations have failed to effect a speedy cure, it is preferable to undertake more extensive measures.

Drainage through a Permanent Intra-nasal Opening. If the antral mucous membrane has not been too seriously damaged this operation

gives most satisfactory results; it is much simpler to perform than the Caldwell-Luc operation, there is no interference with the descending branches of the infra-orbital nerve, infection of the cheek does not occur, and the possibility of the formation of an antro-buccal fistula is avoided.

The operation may be performed under local anæsthesia alone, but in this country a general anæsthetic is usually administered. In the latter case the pharynx and naso-pharynx are packed off. Under good illumination the anterior third of the middle turbinal is removed, or an inverted V-shaped wedge cut out of the inferior border about half an inch behind its anterior end. Many operators consider that partial inferior turbinectomy predisposes to a subsequent atrophic condition; they therefore gain access to the outer antral wall by dislocating the inferior turbinal inwards towards the septum, and replacing it when the antral operation has been completed.

A Tilley harpoon, or a Myles retrograde chisel (see fig. 2537), is then introduced along the floor of the nose, and the point is turned outwards and firmly pushed into the antrum just below the attachment of the inferior turbinal. The barb of the harpoon pulls out any broken pieces of the bony antral wall when the instrument is withdrawn into the nose, and thus prevents these fragments from being pushed into the antrum and acting as foreign bodies. Special care must be taken to ensure that no semi-detached bony fragments remain, for they may later tend to cause a rapid closure of the opening. After the withdrawal of the harpoon the opening is further enlarged by means of a Tilley (or similar) burr, and may be extended in anterior and posterior directions with Ostrum forceps (see figs. 2533 and 2534). The final opening should extend to the floor of the nose, and should be large enough to permit the easy insertion of the forefinger.

The operation is followed by a considerable degree of swelling of the nasal mucous membrane, and if the septal mucosa has been damaged it is probable that adhesions will form. In order to avoid this, I insert a piece of rubber dam against the septum during manipulations with the harpoon and burr, or insert a long speculum so that one blade lies along the lower part of each side of the septum. Owing to the post-operative swelling it may be impossible to irrigate the antral cavity for the first 24–48 hours, but after this a special cannula can be introduced into the opening and lavage of the antrum carried out. In the majority of cases the patient quickly learns to insert the cannula and irrigate his own antrum.

Intra-nasal antrostomy gives excellent results in cases where bony disease or excessive polypoid degeneration of the lining mucous

membrane is absent; in the majority of cases it is worth while giving the patient a chance with this operation, and opening the canine fossa only where the suppuration is not thus arrested.

Caldwell-Luc Operation.

This operation consists in opening the antrum through the canine fossa, removing the diseased antral mucous membrane, and making a large counter-opening into the inferior meatus of the nose. It is indicated in those cases where the simple intra-nasal operation has failed to effect a cure, or where disease of the bony walls of the antrum or markedly polypoidal degeneration of the lining membrane exists. The writer has found it necessary to perform this operation in several cases of maxillary sinusitis of dental origin, even where no marked degenerative changes in the mucous membrane were discovered at the time of operation. The Caldwell-Luc procedure causes considerable shock, particularly in elderly patients, it also has the following disadvantages:

(1) A cellulitis of the cheek may occur as a result of leakage of the infected discharge through the canine fossa opening.
(2) A fistulous opening may persist between the antral and buccal cavities; this may lead to constant re-infection of the antrum from the mouth
(3) Damage may be done to the superior dental branches of the infra-orbital nerve which run down the anterior wall of the antrum; a troublesome form of neuralgia or dental anæsthesia may result.
(4) The approach does not always give good access to the anterior recess of the antrum, and diseased mucous membrane remaining in this situation may be responsible for persistence of the antral discharge.

In order to prevent damage to the superior dental nerves different surgeons have suggested various modifications of the original transverse incision in the labio-gingival sulcus. These will be mentioned in due course.

The technique of the operation is as follows:

After preliminary local anæsthetisation of the nose a general anæsthetic is administered, the patient's mouth is opened slightly with a gag, a sponge is placed in the buccal sulcus, and the pharynx is carefully packed off. The upper lip and the angle of the mouth on the side to be operated upon are then retracted to expose the canine fossa, and an incision is made at the reflection of the mucous membrane from the alveolus to the cheek. The incision should be about one inch in length,

and may be horizontal in direction, or so placed as to try to avoid injury to the superior dental nerves (fig. 2566). The incision must be carried down through the muco-periosteum, which is then reflected off the bone so as to expose the whole canine fossa. Care has to be taken to avoid reflecting the muco-periosteum too far in an upward direction lest the infra-orbital nerve itself be damaged. *A small opening is then made in*

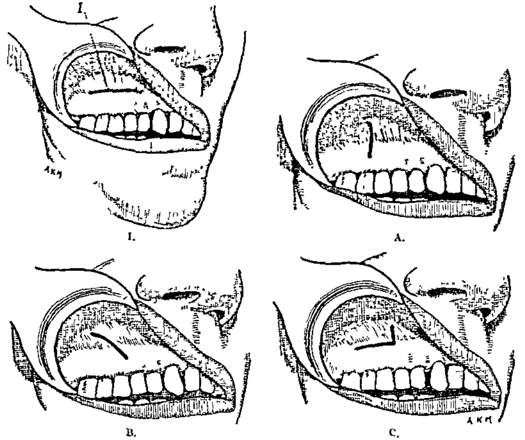


Fig 2566.—Usual and alternative incisions for Caldwell-Luc operation.

I. Usual incision in buccal sulcus.
A. Alternative vertical incision.
B. Carmody's oblique incision in the direction of the branches of the infra-orbital nerve and the fibres of the quadratus labii superioris muscle.
C. Right-angled incision suggested by Monson.

the canine fossa with a gouge and mallet, a probe inserted to ensure that the antral cavity has been entered, and the opening gradually enlarged by means of a large burr until the forefinger can be passed into the antrum (see fig. 2567). Digital palpation will reveal the presence of any polypi or patches of carious bone. The cavity is then mopped out with gauze soaked in hydrogen peroxide until all blood and discharge have been cleared away, and an inspection of the interior is made by inserting a large aural speculum and throwing a strong light through it. Polypi and carious bone may be removed with forceps or by gentle

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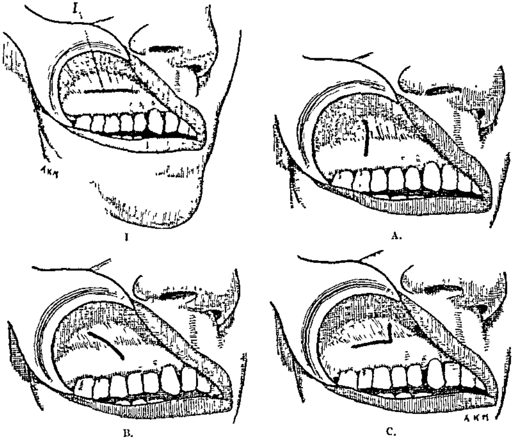

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curettage with a ring-knife, but it is important to curette only diseased mucosa, and not to scrape in a rough or haphazard manner. Some operators recommend removal of the whole of the lining mucous membrane, and state that complete regeneration will follow this procedure; such widespread removal is, however, unnecessary save in the case of a very long-standing infection.

The edges of the opening must be smoothed off, and a careful search made to ensure that any fragments of bone which may have been driven into the antrum are removed. The opening should finally be of sufficient size to enable the operator to make a visual inspection of the nasal wall of the antrum, particularly of the ethmoidal region. Horgan has

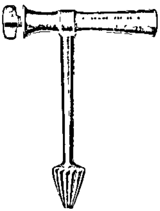

Fig 2567.—Heath's antrum burr.

called attention to the importance of dealing adequately with the infected ethmoidal cells in order to obtain a satisfactory post-operative result.

The next step consists in making a large counter-opening in the antro-nasal wall below the attachment of the inferior turbinal. This wall is broken through, just above the level of the antral floor, by means of a small burr or a gouge, and great care must be exercised to avoid injury to the inferior turbinal at this time. The opening is enlarged with cutting forceps until it is of sufficient size to allow the tip of the index finger to be inserted. It is essential to remove a corresponding area of the mucosa, which if left behind will act as a valve and may interfere with drainage. The surgeon must also make sure that the lower edge of the antro-nasal opening is flush with the floor of the antrum, otherwise incomplete drainage will result. All sponges and pharyngeal packing are now removed, the soft parts over the canine fossa are allowed to fall together, and the edges of the incision approximated with two or three catgut sutures. As a general rule, the antral cavity is left to drain through the antro-nasal opening, but many surgeons make a practice of packing the cavity with ribbon gauze, one end of

which is brought out through the nose. The packing serves to control hæmorrhage, and to promote a reaction which accelerates healing; it is removed at the end of 24 to 48 hours.

After-Treatment.

A considerable degree of swelling of the cheek and lower eyelid may follow the performance of this operation, but this need cause no undue alarm, and it may to some extent be avoided by the application of a pad and firm bandage over the cheek at the conclusion of the operation. Pain may be severe, and should be alleviated by the injection of morphia or heroin. The feeding of the patient may present some difficulties; for the first few days the diet should be a fluid one, and should be swallowed through the opposite corner of the mouth.

After-treatment of the antrum should be reduced to a minimum, and no irrigation should be performed unless there is imperfect drainage. The use of the naso-pharyngoscope will enable one to inspect the antral cavity and to deal with any exuberant granulations which may appear.

The formation of crusts in the nose may be prevented by the instillation of oily drops containing eucalyptus or menthol.

After-Results.

In suitable cases a carefully performed Caldwell-Luc operation usually leads to a rapid and complete cure, but certain disadvantages which attend its performance have already been mentioned. Various modifications have been devised in order to overcome one or more of these disadvantages. Bœnninghaus suggested the reflection of a flap of nasal mucous membrane into the floor of the antrum, to cover the raw lower edge of the antro-nasal opening and a portion of the antral floor. He hoped in this way to promote healing, but such a flap unfortunately tends to become infected, and is apt to swell and thus interfere with the free drainage of the cavity.

In order to obtain adequate access to the anterior, or pyriform, recess of the antrum, Denker advised an operation whereby the opening in the canine fossa is extended inwards until it reaches the anterior margin of the antro-nasal opening. The two openings are thus thrown into one, and efficient exposure and drainage of the cavity are obtained. The disadvantages of Denker's operation are that:

(1) Injury to the superior dental nerves is almost unavoidable, and this may later cause very troublesome neuralgia.
(2) A large amount of bone is sacrificed, and an external deformity may result.

The difficulty of dealing adequately with the anterior antral recess has attracted the attention of many rhinologists, and various ingenious operations have been devised to obtain good access to this region.

The Canfield operation has earned the warm support of Dundas Grant, and an excellent description of his modified Canfield technique is to be found in the *British Medical Journal* of November 15, 1923. Ballenger has also described his modification of the technique in his text-book on *Diseases of the Nose, Throat and Ear.*

Skillern's Operation.

Perhaps the best of such modifications is that suggested by Skillern, who claims that it embodies all the advantages of the Denker and the Canfield-Ballenger operations.

Skillern's description of his operation is epitomised as follows:

(1) The nose and vestibule are cleansed with warm saline.

(2) Cocaine and adrenalin anæsthesia is induced over the anterior attachment of the inferior turbinal above, below, and in front.

(3) A solution of 1 per cent novocaine in 1 in 10,000 adrenalin and saline is injected beneath the mucosa on the nasal side of the pyriform aperture of the antrum, and subperiosteally on the facial aspect of the same structure.

(4) A perpendicular incision is now made, commencing slightly in front of and above the anterior end of the inferior turbinal, and extending well down into the floor of the nose. This incision should sever all the tissues down to the bone. A second curved incision is then made to meet the original incision above and below, so as to excise a spindle-shaped piece of mucous membrane.

(5) Hæmorrhage is controlled with adrenalin tampons, and the periosteum is elevated from the crista pyriformis, both externally towards the canine fossa, and internally towards the inferior turbinal, until a sufficient area of bone has been exposed.

(6) The antrum is now attacked with a chisel having a concave surface. This is applied to the crista pyriformis, first above and then below, and the loosened portion of bone is removed with strong forceps. The aperture is next enlarged with a burr in order to obtain a smooth rounded opening.

(7) The antral cavity is flushed out with lotion, dried with mops, and then firmly packed for five minutes with ribbon gauze soaked in cocaine and adrenalin solution.

(8) A large aural speculum is introduced into the opening, and the interior of the cavity is inspected for polypoid mucosa, patches of granulation tissue, or areas of bony necrosis. The use of a naso-pharyngoscope will often enable a satisfactory visual examination to be made.

(9) All diseased and degenerated mucosa is removed with a curette, and a further careful inspection is made of the floor and the postero-inferior and antero-superior angles of the cavity.

(10) Finally, the antrum is irrigated, and then loosely packed with iodoform gauze.

After-Treatment.

The gauze packing is usually removed at the end of 18 to 72 hours, but it may be left in place for 6 to 7 days if the secretion is slight. After removal of the gauze the cavity is irrigated and then re-packed with iodoform gauze. This is repeated on alternate days for about a fortnight, at the end of which time packing is discontinued. Irrigations and the insufflation of iodoform powder are carried out at increasing intervals for the next four weeks, at the conclusion of which period the ordinary case will be cured. If premature closure of the opening tends to occur, the edges may be touched with silver nitrate or gently curetted. Once the antral infection is cured the opening will gradually close.

B. Operations upon the Ethmoidal Labyrinth

Before entering upon a description of the many ethmoidal operations it may be well to reconsider the vital importance of ethmoidal infection in suppuration of the paranasal sinuses.

Woakes first called attention to the association of nasal polypi with disease of the ethmoid, whilst Hajek later did much invaluable pioneer work on the pathology and clinical manifestations of infection of the ethmoidal labyrinth.

In the *Journal of Laryngology and Otology* (1932, XLVII, 816) Tilley pronounces his dictum that the ethmoid is the "key situation," or "cross-roads," of the nasal sinuses, and that command of this position is the most important factor in a successful attack upon inflammation in any or all of them. He states that "cross-roads" and "dirty work" are proverbially associated, and that experienced operators will not dispute his assertion that more deaths or serious complications have followed operations on the ethmoid cells than those on all the other sinuses put together.

Every rhinologist should read, mark, learn, and inwardly digest Tilley's words which are here quoted :

> "If we bear in mind the close anatomical relationship between the ethmoidal labyrinth and the adjacent large air cells, its proximity to, and vascular connection with, the orbit and its contents, to the optic nerve, to the dural sheaths of the olfactory nerve, and to the meninges—we may well regard that bone with its honeycomb of cells (varying not only in their size, but with an almost infinite capacity for wandering into unexpected regions) as a structure worthy of, and indeed demanding, the closest and most conscientious study."

He then lays down the following rules to be observed when operative treatment of the ethmoidal region is contemplated:

(1) Procure effective ischæmia by the preliminary application of cocaine and adrenalin.

(2) As far as is possible, endeavour to see the diseased areas during operative manipulations. If bleeding be so profuse as to prevent this, further interference should be postponed for a week or ten days, when reactionary swelling and œdema will have subsided. Such reaction will be more obvious if suppuration is present.

(3) In all ethmoidal operations the following is a golden rule: Strive to preserve and keep in view the attachment of the middle turbinal to the "lateral mass," and to work on its external aspect. By so doing you will minimise the chances of damage to the cribriform plate, and to the dural sheaths of the olfactory nerve expansions, both of which are in intimate relationship with the meninges.

(4) No packing should be placed in the operated areas of the ethmoid because free and spontaneous drainage is the paramount object aimed at. Post-operative hæmorrhage is rarely a serious complication.

Tilley concludes his remarks upon the ethmoid with the following words:

"In any operation which entails opening up the ethmoidal labyrinth, the surgeon must bear in mind that its mazes are intricate, and when infected by pyogenic organisms the accurate localisation of the extent of the disease will often tax the diagnostic acumen of the most experienced rhinologist, and its treatment should steady the hand of the boldest operator. He who attacks inflammatory lesions of the ethmoid labyrinth without detailed knowledge of its anatomy and pathology must surely hold very lightly the safety and sanctity of human life."

Ethmoidal operations fall into two classes: external and intra-nasal. At the present time the pendulum is swinging towards external interference, but there are still many fervid supporters of intra-nasal ethmoidal surgery. The animated discussion which followed Ferris-Smith's lecture upon the Management of Chronic Sinus Disease—reported in the *Journal of Laryngology* of August 1935—was most illuminating, but the lecturer's statement, that the patient upon whom he had operated that morning had undergone twenty-one "successful" intra-nasal operations previously and yet had an intact sphenoidal sinus, was a bitter commentary upon the uncertainty of intra-nasal surgery of the ethmoid.

In view, however, of the good results obtained by reputable and experienced rhinologists from intra-nasal operations upon the ethmoidal labyrinth, we must approach the subject with an open mind. The writer personally prefers the external method, but realises that such preference is probably caused by some fault in his technique rather than by any inherent defect in the intra-nasal operation as such. The weight of opinion is that the great majority of infections of the ethmoid can be cured by a carefully-planned and thorough attack from within the nose; but Ferris-Smith claims that no operator, however skilful, can enter all the ethmoidal cells, or safely remove the diseased tissue about the cribriform plate, by intra-nasal manipulations alone.

Intra-nasal Operations on the Ethmoidal Cells.

It is possible that in some cases the ethmoidal disease may be confined to the anterior cells, but there is usually associated infection in the frontal or sphenoidal sinuses, and the majority of intra-nasal ethmoidal operations are merely part of a more extensive interference. Such major measures will be described later in the appropriate chapter; for the present, we will be content to deal with the ethmoidal portion of the operation alone. Broadly speaking, the main steps in the exenteration of the ethmoidal labyrinth by the intra-nasal route are:

(1) Removal of the anterior end of the middle turbinal, and of any associated polypi, as described in a previous chapter.
(2) Clearance of the agger nasi cell or cells. This is effected by means of a sharp spoon or a Hajek hook, pressure being exerted in an outward, and slightly downward and backward, direction.
(3) Opening-up of the ethmoidal bulla.
(4) Curettage of the posterior ethmoidal cells if these be infected.

In this manner the ethmoidal labyrinth may be eviscerated from before backwards, and the fronto-ethmoidal cells cleared by directing the curette so that it cuts against the posterior border of the nasal process of the frontal bone.

Mosher's technique offers the greatest degree of safety, and for his intra-nasal operations on the ethmoid the writer has usually followed Ross Faulkner's modification of this technique. A full description is to be found in Faulkner's article in *The Nose, Throat and Ear, and their Diseases*, edited by Jackson and Coates, but a short account is here given. Faulkner prefers local anæsthesia alone, and performs a preliminary submucous septal resection in order to provide a flexible septum, and thus permit of greater accessibility.

An incision is first made, with a small-bladed knife, along the whole base of the middle turbinal, underneath and external to the body of the bone (fig. 2568). A clean-cut edge of mucous membrane will thus be left at the lower margin of the eviscerated ethmoidal area when the operation is finished. This will facilitate the spread of epithelium over the granulating surface of the os planum. and will also prevent loss of portions of mucous membrane over the middle meatus, which may occur when pieces of the debris are removed with forceps.

The large end of the spade curette is now placed just above the anterior end of the middle turbinal over the cell of the agger nasi (fig. 2569). The upper end of the curette will be just above the level of the inner canthus, and if pressure is now applied directly outwards the curette will enter the agger cell. Its broad surface will prevent its being pushed far enough outward to enter the orbit, an accident which can easily happen with a small curette. Having penetrated the agger cell the operator rotates the curette on its long axis until its concavity faces directly backwards (fig. 2570). and then pushes it back through the whole ethmoidal labyrinth. When the posterior cells have been thus traversed the curette is pressed firmly downwards, and the whole mass of broken ethmoid cells will thus be carried down on to the upper surface of the inferior turbinal (fig. 2571). A pair of Luc or other blunt forceps is then inserted, and the mass is grasped therewith and withdrawn (fig. 2572). If the whole of the turbinal does not come away in the mass it is possible that a portion has been pressed back into the posterior part of a *deep middle meatus, and a careful search* must be made in order to remove it. In many cases it will be found that the curette in its backward sweep has broken down the anterior wall of the sphenoidal sinus; if it has done this, so much the better.

The large end of the ring-curette should now be inserted, and gently moved backwards and forwards over the broken-down area, paying particular attention to the cells just anterior to the fronto-nasal duct (fig. 2573). The small end may be used for these latter cells, and care must be taken to exercise pressure in a forward and downward direction. Considerable pressure with the large ring may be used to break down cells just under the roof-plate of the ethmoid, and those in the postero-external angle.

After-Treatment.

A considerable degree of swelling is almost certain to follow the operation, and it may be some three weeks or more before the patient begins to feel real relief from his symptoms. In the meantime, direct treatment of the nose should be as restricted as possible, but a weak cocaine and adrenalin spray adds to the patient's comfort, and the instillation of hydrogen peroxide drops will help to

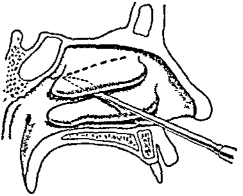

Fig. 2568.—THE DOTTED LINE SHOWS THE INCISION MADE BY THE KNIFE IN THE MUCOUS MEMBRANE BENEATH THE MIDDLE TURBINAL.

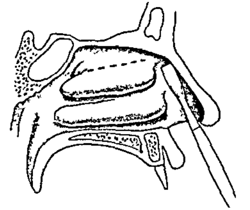

Fig 2569.—THE SPADE CURETTE IS BEING PRESSED OUTWARDS OVER THE AGGER NASI CELLS.

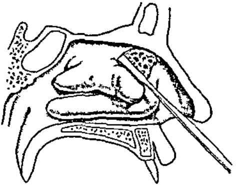

Fig 2570.—*THE CURETTE HAS BEEN TURNED AND IS* EXERTING BACKWARD PRESSURE TO BREAK DOWN THE ETHMOIDAL CELLS AND *THE MIDDLE TURBINAL*

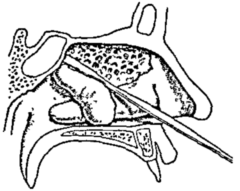

Fig 2571.—THE CURETTE HAS BEEN PRESSED BACKWARDS AND DOWNWARDS AND IS CARRYING THE BROKEN *CELLS AND THE MIDDLE TURBINAL BEFORE IT.*

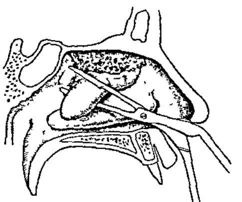

Fig 2572.—THE MASS OF BROKEN CELLS AND MIDDLE TURBINAL GRASPED BY FORCEPS.

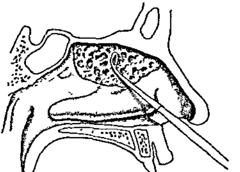

Fig 2573.—THE ETHMOID CURETTE IS BEING USED TO COMPLETE THE BREAKING DOWN OF THE CELLS AND TO SMOOTH THE BONY SURFACES

(*Modified from Ross Faulkner*)

loosen any sticky secretion. If the secretion is excessive the nose may be gently irrigated with a warm alkaline lotion, but in no circumstances must forcible syringing be undertaken. Exuberant granulations may require removal with a curette, and if, by chance, any infected cells have been overlooked they must be dealt with after the post-operative swelling has subsided. In the majority of cases this procedure will effect a cure, and the removal of the middle turbinal does not lead to the atrophic condition in the nose which follows inferior turbinectomy.

Dangers of the Operation.

If necrosis of the cribriform plate is present, or if this region is penetrated by the curette during the operation, meningitis is very liable to occur, and almost invariably proves fatal. It is, therefore, of the utmost importance to operate only with the best possible visibility, to avoid upward and inward pressure with the curette, and always to keep the attachment of the middle turbinal in view. In some cases the onset of the meningitic symptoms may be delayed for as long as two or three weeks after the operation.

Penetration of the orbital cavity may occur during exenteration of the agger cell, and alarming hæmorrhage may take place and be followed by marked proptosis. Fortunately the blood usually absorbs without suppuration if the infected cells have been thoroughly cleared out.

Sudden blindness may result in the course of the operation, due to the optic nerve being injured by manipulations in the posterior ethmoidal angle. For this reason the use of cutting forceps in this area should be avoided.

A number of cases of osteitis and osteomyelitis have been recorded as following intra-nasal operations upon the ethmoidal labyrinth.

External Operations on the Ethmoidal Cells.

Where intra-nasal methods have failed to effect a cure, or where complications such as orbital abscess or fistula have appeared, an external operation is indicated. Exenteration of the ethmoidal labyrinth is an integral part of such operations as Howarth's and Ferris-Smith's, which will be described when the treatment of multi-sinusitis is considered; but for the present the ethmoidal part of the operation will alone be dealt with. When the ethmoid only is involved I usually follow Kisch's technique, which also gives access to the lower part of the frontal sinus, and was, in fact, originally described as "a new frontal sinus operation" (*Journal of Laryngology and Otology*, June 1928). The illustrations have been adapted from Kisch's original paper.

A curved incision, about 1 inch in length, is made from just internal

to the supra-orbital notch forwards and downwards, and medial to the internal canthus of the eye (fig. 2574). The incision is carried down to the bone, and hæmorrhage, which may be troublesome, is controlled. The periosteum is reflected so as to expose the ascending process of the superior maxilla, but the orbital contents are not retracted. If an orbital abscess or fistula is present, the bony perforation is enlarged with a chisel; if not, a portion of the ascending process of the superior maxilla is removed by means of a chisel. A transverse cut is first made low down, and then an upper one; these are joined by the two vertical cuts

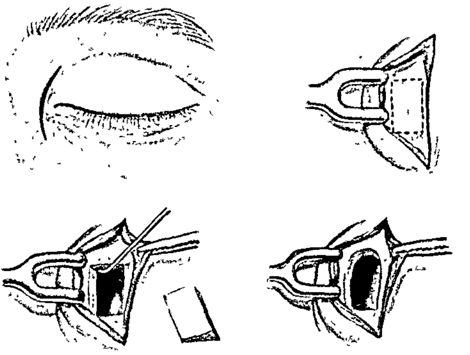

Fig 2574.—The essential steps of Kisch's operation for exposure of left ethmoidal cells and frontal sinus.

as in figure 2574, and the isolated bony fragment is removed with forceps. The opening of the fronto-nasal duct is thus immediately exposed, and pus may exude from it if the frontal sinus is infected. More room in a downward direction is now obtained by further removal of bone at the lower margin of the aperture, and the ethmoidal cells are then broken down. These cells may be followed backwards as far as the sphenoidal sinus and adequately dealt with; *finally, a large opening is made into the nose through the bulla* ethmoidalis.

The external wound is then carefully closed with clips or fine silkworm-gut. Kisch considers that no drainage-tube is necessary, and that

the only after-treatment required is spraying of the nose with collosol iodine, and perhaps occasional gentle lavage with an alkaline nasal wash.

C. Operations upon the Frontal Sinuses

Layton has said that there is no such thing as an isolated frontal sinusitis. but that it is always a fronto-ethmoiditis. He states categorically that from anatomical. pathological and clinical points of view frontal sinusitis is no entity. Anatomically—because, of some four flask-shaped primitive ethmoidal cells. the frontal sinus is but one which has happened to reach the vertical part of the frontal bone in the excursion of the whole group from the front end of the primitive semilunar groove; pathologically—because all four cells are involved; and clinically—because the separate treatment of the frontal sinus by the passage of a frontal sinus cannula is impossible, except in a small number of persons whose anatomy is such that they will probably never develop a chronic inflammation in the cavity. He has even made a gallant attempt to elevate the maxillary sinus to the post of dishonour, or "key-position," which is usually attributed to the ethmoid; his conclusions certainly merit serious consideration.

St. Clair Thomson, however holds that in many cases of chronic disease the fronto-ethmoidal cells have become degenerated to such an extent that the pressure of the catheter breaks them down, and thus permits the catheter to be passed into the sinus.

It is, nevertheless, very doubtful whether irrigation through a cannula can effect a cure in cases of chronic frontal sinusitis; to realise this one has but to inspect the polypoid mucosa which is exposed in the course of an external operation, and to remember the associated infection of the ethmoidal cells, which are not accessible for lavage.

Catheterisation of the frontal sinus as a method of treatment has therefore been practically abandoned, except in the case of elderly patients who decline operation, or upon whom operative interference is considered inadvisable.

Intra-nasal Operations.

The simplest form of intra-nasal operation has already been described in the section dealing with treatment of chronic ethmoiditis, and has for its object the elimination of the ethmoidal disease which is obstructing drainage through the fronto-nasal duct. Should such measures be insufficient, a more extensive procedure is indicated, and the ostium of the duct must be enlarged. For this purpose special bougies are passed into the ostium after the preliminary ethmoidal operation, and the degree of patency of the ostium is determined. If a bougie of

a diameter of about 6 mm. will not pass through, an attempt must be made *to enlarge the passage by removing some of its anterior* wall, formed by the nasal crest, by means of special raspatories. In so doing it must be remembered that the anterior cranial fossa dips slightly into the nasal roof; this is the "danger area," and is more liable to be injured if the head is in the extended position. It is also *important to work in only an outward and forward direction* with the raspatory, for if the instrument slips inwards it may well damage the cribriform plate and lead to meningitis.

When the ostium has been sufficiently enlarged the surgeon can irrigate the sinus periodically through a cannula, though occasional dilatation with a bougie may be required.

Such intra-nasal operations are by no means devoid of risk, and a number of fatalities have been recorded after their performance. There are, however, many rhinologists who claim most satisfactory results therefrom, and who reserve external operation for those cases in which some complication has arisen. It is certain that the external deformity and the osteomyelitis which tended to follow such operations as that of Killian caused *a swing-back of the pendulum towards intra-nasal* methods, but, with the introduction of Howarth's and similar operations, many surgeons (of whom the writer is one) now consider that the results obtained by the external method of approach are definitely superior.

External Operations.

The main indications for external operation are:

(1) Failure of intra-nasal methods to effect a cure, particularly if symptoms of retention of pus in the sinus persist.
(2) Prolonged foul discharge leading to deterioration of the patient's general health.
(3) Recurrent attacks of facial erysipelas.
(4) The presence of intra-cranial complications, or of orbital abscess or fistula.

Operations such as those of Kuhnt, Jansen, and Ogston-Luc have now been abandoned, whilst Killian's operation, which superseded them, has in its turn given way to the methods devised by Howarth, Harmer, and Ferris-Smith.

Killian's operation *aimed at the complete* exposure of the frontal sinus and its subsequent obliteration, whilst at the same time all *infected ethmoidal* cells were destroyed, and free drainage into the nose was established. It represented a distinct advance on the older

methods, but was not entirely free from defects and dangers. Unless a supra-orbital "bridge" was left, an unsightly external deformity ensued in most cases, whereas if a bridge were left it was liable to necrose or to lead to the onset of spreading osteomyelitis.

A description of *Killian's operation has hitherto been found in* every text-book of nasal surgery, but the writer does not propose to include it here; in his opinion, it must in its turn be relegated to its honourable place in the history of surgery of the sinuses.

Howarth's Operation.

This was devised by Howarth *in order to avoid the disadvantages* of such procedures as the Killian and Ogston-Luc operations.

In the Killian operation an attempt is made to obliterate the frontal sinus completely by removal of its anterior wall and its floor. In many cases, however, complete obliteration is not feasible and "dead spaces" are apt to remain, and to lead to osteomyelitis. *Such spaces are found particularly behind the supra-*orbital "bridge," and in the ethmoidal region. Moreover, owing to the loss of bony support the soft tissues tend to fall in, and permanent disfigurement may result.

The Ogston-Luc operation shares with the Killian the disadvantage due to removal of the anterior sinus wall with consequent likelihood of the supervention *of osteomyelitis; in addition it does not provide adequate exposure of the* ethmoidal region, nor does it enable the operator to make a sufficiently large opening into the nose.

The advantages of Howarth's operation are:

(1) The resultant scar is a fine one, and as it is situated in a shadowed position it is frequently almost invisible. The anterior wall of the frontal sinus is not removed, so that no unsightly depression occurs.

(2) Surgically it is possible to deal thoroughly with the most complicated cases of fronto-ethmoidal suppuration. The ethmoidal cells may be fully exposed, and the sinus drained through a large opening which lies directly below its floor.

A description of Howarth's operation is given in the *Journal of Laryngology and Otology*, XXXVIII, 342, from which I now quote:

"A curved incision is made just under the supra-orbital margin, and brought down in front of the inner canthus on to the side of the nose. The skin being very thin in this region a fine scar is obtained; moreover, as it is in this situation that the shadow falls, often the scar is almost invisible. The incision is carried down to the periosteum; bleeding from the numerous branches of the angular vein is usually

very free, but is readily controlled. The periosteum is incised in practically the same line as the skin incision, and, with a Farabœuf's rugine or other suitable instrument, the periosteum covering the roof and inner wall of the orbit is then raised; the pulley of the superior oblique is thus detached from its notch, and the whole of the orbital contents displaced outwards; similarly, the lachrymal sac is displaced from its groove, and retracted outwards with the orbital contents. The appearance is then somewhat as in figure 2575. The sinus is now opened in the situation where one is always sure to find it (dotted circle in fig. 2575), just above the lachrymal groove.

"With Citelli bone forceps the whole of the floor of the sinus is now removed right up to the supra-orbital margin. If long narrow galleries are seen to project backwards in the roof of the orbit, or outwards

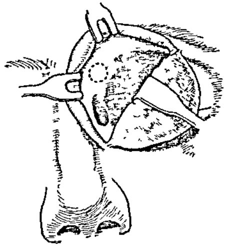

Fig 2575.—Howarth's operation. Incision and exposure of frontal bone.

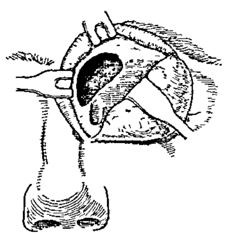

Fig 2576.—Howarth's operation. Showing opening into frontal sinus.

towards the external angular process, their floor is usually thin, and may be completely removed with a strong pair of Luc forceps. The lining mucosa should be disturbed as little as possible. The portion lining the floor will, of course, be removed with the bone, but that which lines the dome of the cavity should be left intact. Attention is now turned to the region of the fronto-nasal duct. A copper bougie is, if possible, pushed up it from the nose to act as a guide. With the Citelli forceps the bone in front of the fronto-nasal duct (that is to say, part of the ascending process of the frontal bone) is removed, so that the appearance is as in figure 2576; and the operator is in a position to see whether any ethmoidal cells are mounting up into the floor of the frontal sinus, or overlying the fronto-nasal duct.

"The ethmoid is then attacked, entrance being effected through the lachrymal groove. After the anterior cells have been removed it

will probably be found satisfactory to employ a bimanual method, the ethmoidal cells being broken upwards from below by means of a mastoid curette applied intra-nasally, the debris being removed through the external wound with Luc forceps held in the other hand.

"The ethmoid cells are followed backwards if necessary to the sphenoid. Often a series, stuck like barnacles to the base of the skull, may require careful opening, and it is sometimes a matter of considerable difficulty to decide whether one has really reached the base of the skull, or whether another flat ethmoidal cell still intervenes. The picture will then be somewhat as in figure 2577.

"An important part of the operation still remains to be done. This consists of making a new fronto-nasal duct further forward than the old one. In order to effect this, further portions of the ascending

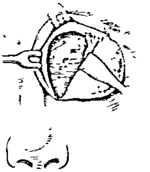

Fig. 2577.—Howarth's operation showing condition after "clearing up" of ethmoidal cells.

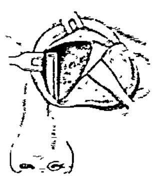

Fig. 2578.—Howarth's operation. Drainage-tube in position after completion of bony part of operation.

(By kind permission of Mr. Walter Howarth.)

process of the superior maxilla, and of the nasal process of the frontal bone, must be removed with gouge and forceps, particular attention being paid to the boss which projects backward from the frontal bone.

"A large firm-walled rubber drainage-tube pushed up the nose will lie well forward as in figure 2578. The upper end is tucked into the anterior part of the sinus, and the lower end stitched to the ala of the nose. The orbital contents are then allowed to fall back into place, and the incision completely sutured with the finest silkworm-gut. The tube is removed at the end of ten days."

Since Howarth wrote the above account his technique has not been changed save for the insertion of a skin graft to cover the raw surfaces of the new fronto-nasal duct.

The writer would like to pay his tribute to this operation, which he has performed on several occasions with excellent clinical and cosmetic results. In a recent case, however, he has experienced great trouble

and a poor result, owing to the extreme narrowness of the upper part of the nose rendering manipulations excessively difficult. In this patient, however, it is probable that any other operation would have presented the same disadvantage, and that the operator's lack of experience was the main cause of failure.

Harmer's Operation.

A description of this operation is given by Harmer and Bedford Russell in the *Journal of Laryngology and Otology*, June 1931, 384. It differs from other external operations on the frontal sinus in that its principle is the gradual dilatation of the fronto-nasal duct by elastic pressure, which is applied so slowly that injury to the mucous lining of the duct is avoided.

The technique is as follows:

Local intra-nasal anæsthesia is induced, and then, under a general anæsthetic, an incision about $\frac{3}{4}$-inch in length is made immediately below the inner end of the eyebrow. Care must be taken to avoid injury to the supra-orbital nerve, lest troublesome neuralgia persist as a result of the involvement of the nerve fibres in the scar. All the soft tissues, including the periosteum, are then divided just above the supra-orbital margin, bleeding is controlled, and the periosteum is reflected upwards. A self-retaining retractor is next introduced, and with a small gouge and mallet an opening into the sinus is made above the supra-orbital ridge, and enlarged by means of a burr or bone-forceps. This opening should be sufficiently large to admit the tip of the little finger, and its centre should be $\frac{3}{8}$-inch from the middle line. The edges of the wound having been smeared with B.I.P.P., the mucosa of the sinus is opened, and any secretion removed by suction. A curved silver probe is next passed down from above via the infundibulum into the nose, and its lower end is grasped with forceps and brought out through the anterior naris. If difficulty is experienced in passing the probe it may be necessary to amputate the anterior third of the middle turbinal, and to exenterate the agger cell or cells. Difficulty in finding the lower end of the probe may be met with unless the probe is sufficiently curved to throw its lower end well forward. As the success of this operation depends to a great extent upon the avoidance of trauma within the fronto-nasal duct, it is important to exert no undue force in passing the probe into the nose. A long piece of stout thread is now tied to the lower end of the probe, and the latter is withdrawn through the nose and infundibulum so as to pull the thread out through the supra-orbital wound. A small soft rubber catheter is attached to the lower end of the thread, and is in its turn pulled up through the

infundibulum into the wound. If great difficulty is experienced in pulling the catheter through, undue trauma must be avoided; it is preferable to leave only the thread in position for a day or two until the intra-nasal congestion has subsided, when the introduction of a catheter will be comparatively easy. The tip of the catheter is then cut off, and may be stitched transversely to the upper end of the rest of the catheter in order to prevent its slipping down into the nose. The external wound is then smeared with B.I.P.P., but is not closed by sutures, as it is most important to maintain free drainage above and below during the early stages of the post-operative treatment. A light dressing is applied over the wound, and this should be frequently changed.

This operation takes but a short time to perform, and causes so little shock to the patient that he need stay in bed for only a day or two.

After-Treatment

For about a week after operation the sinus is irrigated with saline through the catheter; at the end of this time the tube is usually loose enough to enable one to replace it by a larger catheter, and in this way a gentle and gradual dilatation of the duct is effected. As a general rule, one begins with a No. 3 catheter, and works up slowly until a No. 9 or 10 can be passed into the duct. For the first ten days or so the upper end of the tube should project through the supra-orbital wound, but if prolonged intubation is required the tube need later be drawn up only into the sinus cavity, where it is anchored in position by tying the thread to a rubber button which is placed on the forehead.

By this simple operation it is possible permanently to dilate the frontal infundibulum, and in many cases the patient can himself pass a cannula and wash out his sinus regularly. Bony absorption takes place round the tube, but the mucosa of the canal is not injured, and does not tend to contract once the tube has been removed. Even if a complete cure is not effected, relief from pain and the cessation of discharge are almost certain to follow.

D. Operations upon the Sphenoidal Sinus

Irrigation of this sinus may be carried out by means of a special sphenoidal cannula through the natural ostium, or after puncture of the anterior wall by a trocar. In some cases of atrophic rhinitis this procedure may be successfully adopted without removal of the posterior part of the middle turbinal, but in other patients both middle turbinectomy and a septal resection may be required before an instrument can be inserted through the nose into the sinus.

Should irrigation prove unsuccessful, more extensive surgical measures may have to be adopted, in order to remove the diseased tissues and to establish adequate drainage of the sinus. It must be

remembered that sphenoidal sinus suppuration is intimately associated with disease of the posterior cells of the ethmoid, and the treatment of both conditions should be undertaken at the same time.

Intra-nasal Operation.

Hajek's technique, or some modification thereof, is usually followed, and the manipulations are preferably carried out under local anæsthesia. Cocaine and adrenalin solution is applied to the septum, the upper and middle meatuses, and the anterior wall of the sphenoidal sinus. If there be a marked septal deflection, a submucous resection is performed and the posterior half of the middle turbinal is removed. Under the best possible illumination a Hajek hook is then introduced into the sphenoidal ostium, and pulled forwards in order to break down

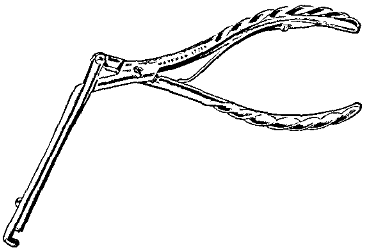

Fig 2579.—Lack's sphenoidal sinus punch

the anterior sinus wall; the bony fragments are taken away with suitable forceps. Removal of the whole of the anterior sinus wall may be accomplished with Lack's sphenoidal cutting forceps (fig. 2579), but the operator must remember the possibility of damaging the spheno-palatine artery during these manipulations. The interior of the sinus is now examined for polypi or granulation tissue; if present, these are gently scraped away with a curette, and the posterior ethmoidal cells are similarly dealt with. It is, of course, essential that all manipulations with the curette in this area should be as gentle as possible, as the optic nerve or the cavernous sinus may easily be injured.

After-Treatment.

This consists in irrigating the cavity, and ensuring that no contraction of the opening occurs. The patient is unable to carry out such treatment himself, and the surgeon must therefore irrigate the sinus daily for about a week, and occasionally touch the edges of the opening with silver nitrate in those cases where premature contraction appears. At the end of 7 to 10 days irrigations may be repeated twice weekly for about a month, and the cavity be swabbed out with

cotton-wool pledgets soaked in a 2 per cent solution of copper sulphate or silver nitrate. In some cases the tendency of the opening to contract may be so great as to necessitate further removal of bone with the cutting forceps.

The results of this operation are, on the whole, very good, and external methods are seldom indicated except in the case of multi-sinusitis. The sphenoidal sinus may, however, be fully exposed by external approach, particularly by Ferris-Smith's operation which will now be described.

E. Ferris-Smith's Operation upon the Paranasal Sinuses

It is unfortunately true that many patients remain uncured even after submitting to several operations for the relief of chronic sinusitis, and the "chronic nose" is to-day as well established an entity as the "chronic abdomen."

It is pre-eminently in such cases that Ferris-Smith's operation affords a good prospect of cure, and every rhinologist who was privileged to hear his lecture upon "The Management of Chronic Sinus Disease," given before the Laryngological Section of the Royal Society of Medicine on February 1st, 1935, must have been imbued with new hope for the treatment of this distressing malady. A report of the lecture and the subsequent discussion is to be found in the *Journal of Laryngology and Otology* of August 1935, pages 604 *et seq.*, and the following description of the technique of the operation is taken therefrom. The excellent lantern slides depicting the steps of the operation are here represented by the accompanying illustrations.

The principle of the operation is an approach to the diseased areas in a practically bloodless field, with complete exposure of the affected cavities under full vision. Ferris-Smith claims that only by this method can every diseased cell be adequately dealt with. He insists upon the removal of all diseased mucous membrane, and states that microscopical examination of several hundred infected sinus walls has never shown one which is fit for retention. He contends that in view of the findings of Pickworth (*Journal of Laryngology and Otology*, 1932, XLVII, 797) one can no longer dare to treat the sphenoidal sinus conservatively, but must remove its lining completely. Moreover, he stresses the importance of the insertion of a skin graft in order to prevent contraction of the new fronto-nasal duct.

Ferris-Smith's account of his technique is as follows:

"The face is cleansed with soap and water, painted with 3 per cent iodine, and finally sponged with alcohol to remove the iodine. A black helmet, which exposes only the operative field, is drawn over the face and head, and fastened with strings about the neck. This draping absorbs the light about the operative field and increases the illumina-

tion in the depths. The side of the nose to be operated on is packed with cotton pencils wrung out of a solution of epinephrine hydrochloride (1 in 2000) containing 10 per cent of cocaine. The area of the incision about the inner canthus of the eye is infiltrated with a solution of 2 per cent procaine hydrochloride containing 25 minims of epinephrine hydrochloride to the ounce. Two or three drachms of this solution is sufficient. The eyelids are closed by a horse-hair suture

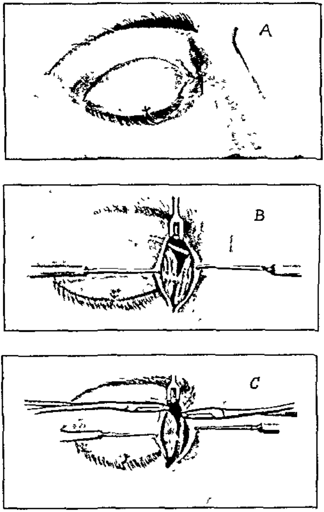

Fig 2580.—IN A THE DOTTED LINE INDICATES THE SKIN INCISION, THE LIDS ARE CLOSED BY A HORSE-HAIR SUTURE. B SHOWS THE EXPOSURE OF THE SUPERIOR PALPEBRAL VESSELS. C SHOWS DIVISION AND LIGATION OF THE SUPERIOR PALPEBRAL VESSELS.

(*By kind permission of Dr Ferris-Smith.*)

passed through the marginal skin of the upper and lower lids. This protects the cornea from damage by sponges and instruments. The dotted line in figure 2580A indicates the incision in the skin. This should begin immediately below the eyebrow. The incision should be about $\frac{3}{4}$-inch long and terminate $\frac{3}{8}$-inch below the canthus. It should be staggered or offset at its mid-point to prevent scar elevation. The elevation of the skin and fascia on either side of the incision exposes the apposition of the orbicularis palpebrarum and quadratus muscles

cotton-wool pledgets soaked in a 2 per cent solution of copper sulphate or silver nitrate. In some cases the tendency of the opening to contract may be so great as to necessitate further removal of bone with the cutting forceps.

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The principle of the operation is an approach to the diseased areas in a practically bloodless field, with complete exposure of the affected cavities under full vision. Ferris-Smith claims that only by this method can every diseased cell be adequately dealt with. He insists upon the removal of all diseased mucous membrane, and states that microscopical examination of several hundred infected sinus walls has never shown one which is fit for retention. He contends that in view of the findings of Pickworth (*Journal of Laryngology and Otology*, 1932, XLVII, 797) one can no longer dare to treat the sphenoidal sinus conservatively, but must remove its lining completely. Moreover, he stresses the importance of the insertion of a skin graft in order to prevent contraction of the new fronto-nasal duct.

Ferris-Smith's account of his technique is as follows:

"The face is cleansed with soap and water, painted with 3 per cent iodine, and finally sponged with alcohol to remove the iodine. A black helmet, which exposes only the operative field, is drawn over the face and head, and fastened with strings about the neck. This draping absorbs the light about the operative field and increases the illumina-

tion in the depths. The side of the nose to be operated on is packed with cotton pencils wrung out of a solution of epinephrine hydrochloride (1 in 2000) containing 10 per cent of cocaine. The area of the incision about the inner canthus of the eye is infiltrated with a solution of 2 per cent procaine hydrochloride containing 25 minims of epinephrine hydrochloride to the ounce. Two or three drachms of this solution is sufficient. The eyelids are closed by a horse-hair suture

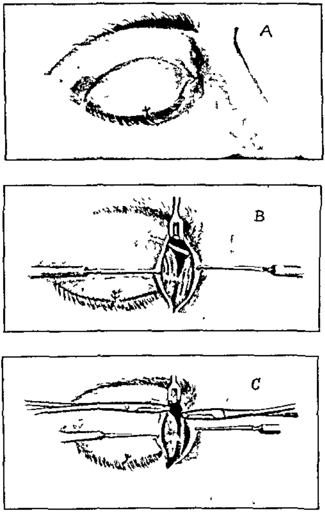


Fig 2580.—In A the dotted line indicates the skin incision, the lids are closed by a horse-hair suture. B shows the exposure of the superior palpebral vessels. C shows division and ligation of the superior palpebral vessels.

(*By kind permission of Dr Ferris-Smith*)

passed through the marginal skin of the upper and lower lids. This protects the cornea from damage by sponges and instruments. The dotted line in figure 2580A indicates the incision in the skin. This should begin immediately below the eyebrow. The incision should be about $\frac{3}{4}$-inch long and terminate $\frac{3}{8}$-inch below the canthus. It should be staggered or offset at its mid-point to prevent scar elevation. The elevation of the skin and fascia on either side of the incision exposes the apposition of the orbicularis palpebrarum and quadratus muscles

(see fig. 2580B). These are separated in order to expose the superior palpebral vessels which branch from the angular vessels in the quadratus muscle. At this point the internal canthal ligament is seen.

The superior palpebral vessels are incised between two forceps and ligated with No. 00 plain catgut (see fig. 2580C). The incision is carried through the periosteum to the bone. The periosteum is elevated on the lateral side of the incision until the ligaments about the lachrymal sac are exposed. These are incised, and the sac is turned outwards and downwards until the duct is exposed in the floor of the fossa. The periorbita is freed by an elevator from the entire lamina papyracea and the floor of the frontal sinus. Care must be exercised not to tear the periorbita along the fronto-ethmoid suture, to which it is frequently

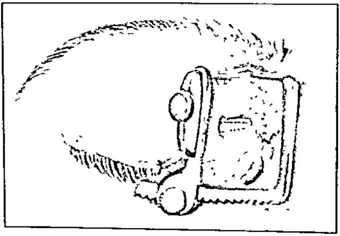


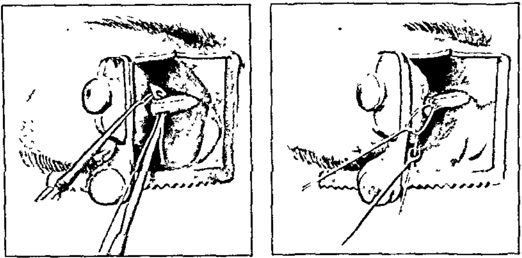
Fig. 2581.—The periorbita is separated from the lamina papyracea and the frontal floor. The posterior ethmoidal vessels and nerve are exposed.

(*Ferris-Smith.*)

firmly attached. This elevation exposes the posterior ethmoidal vessels and the nerve sheathed in the periorbita which is firmly attached about the posterior ethmoid foramen. A self-retaining tractor with a slotted blade of suitable size (fig. 2581) is passed over the posterior ethmoidal vessels and opened to expose the entire lamina papyracea. This traction puts the sheaths of these vessels on tension and makes their ligation a simple procedure. At this point cotton-wool applicators wrung out of 10 per cent cocaine solution are applied for a few moments above and below the sheath to anæsthetise the posterior ethmoid nerve. A right-angled Yankauer needle, carrying No. 0 plain catgut, is passed through the sheath posterior to the vessels and close to the retractor. The end of the suture is recovered with a sharp hook (fig. 2582A). The knots are formed outside the orbit, and passed into position by a slotted ring-tier (fig. 2582B). The vessels are ligated by the method described by Sewall and incised at the bony foramen. The distal ends rarely bleed

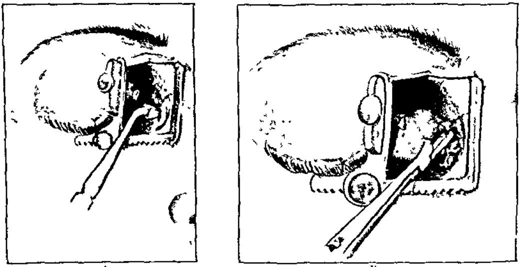
more than a few drops, but in the most troublesome case the bleeding may be controlled by a few moments' pressure with a gauze sponge.

"The mesial orbital wall is perforated through the lachrymal fossa, or immediately behind it, with a sharp perforator large enough to admit



A B.

Fig 2582.—A shows ligation of the posterior ethmoidal vessels. A needle, carrying No. 0 catgut, has been passed through the periorbita posterior to the vessels, and the suture is being recovered by a sharp hook. In B the catgut knots are tied outside into position with a slotted ring.



A B

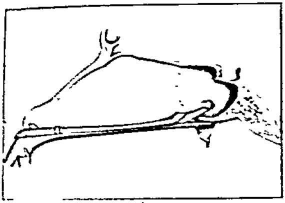
Fig 2583.—A shows perforation of the lamina papyracea to admit a punch forceps, B, removal of the lamina papyracea with the punch forceps

(*Ferris Smith*.)

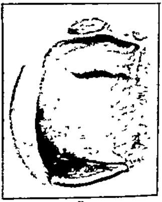
punch forceps, with which the opening is further enlarged (fig. 2583A). With specially designed heavy punch forceps enough of the posterior margin of the nasal process of the maxilla is removed to permit complete exenteration of the lining of the most anterior cell and to afford a clear view. The lamina papyracea is now removed with Grunwald

any form of punch forceps, but it can always be accomplished with a motor-driven cross-cut burr.

"The lining is now completely removed with a dull separator and small balls of gauze. If the membrane is resistant, as is frequently the case, the cavity is packed for a few minutes with gauze soaked in the trinitrophenol solution, after which the membrane is readily separated, except in the case of pterygoid pneumatisations. The flap is folded over the remaining portion of the floor to furnish a lining and prevent



A



B

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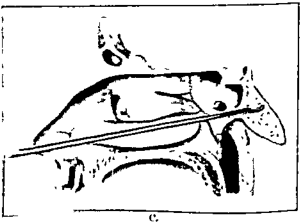


C

granulations on the cut edge (fig. 2587B). If the basilar process and articular process of the occipital bone are the site of an infection or an osteomyelitis, this area is treated exactly as one treats a long bone in similar circumstances. A burr, introduced through the nostril and controlled under direct vision through the orbital opening, is used to cut a channel to the superior cortical wall

... sinus is now entered in the region of its normal opening
... removed with punch forceps and rongeurs (fig. 2588).
... the junction of the two tables is bevelled, so that

parallel with the nasal roof in removing the superior portion of this wall. If it is introduced at an angle through the nostril, the distal blade will lie high in the dome-shaped roof of the cavity, and part of the cranial floor will be removed. The muco-periosteum containing the spheno-palatine vessels is now *separated from the lower remnant of the wall (fig. 2585)*

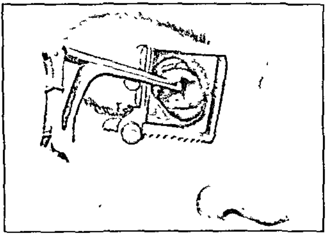
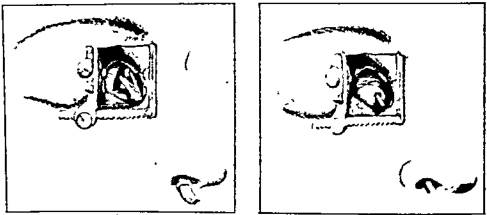


Fig 2585.—The anterior wall of the sphenoid sinus is being removed by a punch forceps passed through the orbital opening (*Ferris Smith.*)

preparatory to the removal of as much of the floor as possible. A Yankauer needle carrying No. 0 plain catgut is passed behind the vessels near the nasal septum (fig. 2586A). The ligature is recovered with a sharp [illegible] and tied as described for the posterior ethmoidal vessels

punch forceps (see fig. 2583B), leaving a wall $\frac{3}{16}$-inch high along the orbital floor when the condition of the bone permits. The same forceps introduced through the nostril remove the major portion of the ethmoid cells and leave the lateral wall of the middle turbinate clearly exposed. A Sluder ethmoid knife is now gently inserted between the septum and the middle turbinate, and raised to the level of the cribriform plate. It is turned laterally to fracture the turbinate slightly towards the orbital wall. The punch forceps are introduced with the female blade along the cribriform plate, and the middle turbinate is



A. B.

Fig. 2584.—In A the lamina papyracea and the ethmoidal labyrinth have been removed; the middle turbinal is being removed by a punch forceps. In B the ethmoid foveæ in the frontal bone are seen along the nasal roof. The anterior wall of the sphenoid sinus is exposed; a hook knife is enlarging the sphenoid ostium.

(*Ferris-Smith.*)

punched away without tugging or tearing. The bevel of the female blade of the forceps protects the cribriform plate from damage (fig. 2584A).

"The complete removal of the middle turbinate has exposed the entire anterior wall of the sphenoidal sinus. The remnants of the ethmoid cells are completely removed with punch forceps, and the nasal roof (fovea frontalis) is completely freed from covering membrane by the use of small gauze balls instead of metal curettes. Every vestige of membrane must be cleared away and the bone left scrupulously clean. Any adherent shreds will be freed by a solution of 5 per cent trinitrophenol in 35 per cent acetone, which is thoroughly applied to the entire operative area.

"One now deals with the sphenoid sinus. A Sluder knife is introduced into the ostium and the opening enlarged laterally to admit punch forceps (fig. 2584B). The anterior wall is completely removed from the roof to a point about $\frac{3}{16}$-inch above the floor (fig. 2585). The punch forceps should be introduced through the orbital opening and held

parallel with the nasal roof in removing the superior portion of this wall. If it is introduced at an angle through the nostril, the distal blade will lie high in the dome-shaped roof of the cavity, and part of the cranial floor will be removed. The muco-periosteum containing the spheno-palatine vessels is now separated from the lower remnant of the wall (fig. 2585)

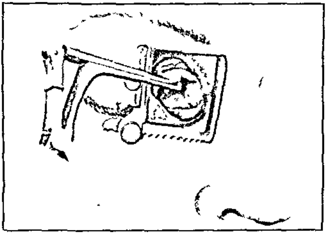


Fig. 2585.—The anterior wall of the sphenoid sinus is being removed by a punch forceps passed through the orbital opening (*Ferris-Smith.*)

preparatory to the removal of as much of the floor as possible. A Yankauer needle carrying No. 0 plain catgut is passed behind the vessels near the nasal septum (fig. 2586A). The ligature is recovered with a sharp hook and tied as described for the posterior ethmoidal vessels.

A B. C

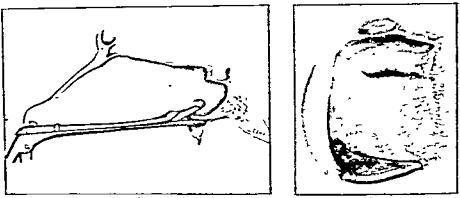
Fig 2586.—A shows ligation of the spheno-palatine vessels near to the vomer, B, the formation of a muco-periosteal flap to expose the bony floor of the sphenoid cavity, C, the removal of the bony floor with a heavy punch forceps.

(*Ferris Smith.*)

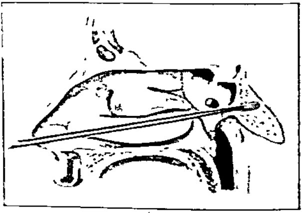
This ligation may be easily accomplished with the Ferris-Smith automatic needle. A flap of muco-periosteum is formed by carrying an incision backwards and slightly outward from the nasal septum. This flap is separated from the floor of the sinus (fig. 2586B). The floor is removed until the remaining portion, together with the posterior wall, describes a parabola directed into the naso-pharynx (fig. 2586C). This is frequently difficult, and sometimes impossible, to accomplish with

any form of punch forceps, but it can always be accomplished with a motor-driven cross-cut burr.

"The lining is now completely removed with a dull separator and small balls of gauze. If the membrane is resistant, as is frequently the case, the cavity is packed for a few minutes with gauze soaked in the trinitrophenol solution after which the membrane is readily separated, except in the case of pterygoid pneumatisations. The flap is folded over the remaining portion of the floor to furnish a lining and prevent



A B



C.

Fig. 2587.—A shows a lateral view of the removal of the bony floor of the sphenoid cavity. In B the mucoperiosteal flap is reflected over the remaining bony floor. In C a burr is introduced through the nostril and carried to the superior cortical wall.
(*Ferris Smith.*)

granulation on the cut edge (fig. 2587B). If the basilar process and articular process of the occipital bone are the site of an infection or an osteomyelitis this area is treated exactly as one treats a long bone in similar circumstances. A burr, introduced through the nostril and controlled under direct vision through the orbital opening, is used to cut a channel to the superior cortical wall (fig. 2587C).

"The frontal sinus is now entered in the region of its normal opening and the entire floor removed with punch forceps and rongeurs (fig. 2588). The angle formed by the junction of the two tables is bevelled, so that

no crevices remain. The lining and the posterior bony wall are treated in the same manner as in the sphenoid sinus.

"Only rarely is it necessary to enlarge the incision in the soft parts to permit access to an abnormally extensive sinus.

"Two points of importance remain. The lining in moderately or abnormally high anterior portions of the sinus may be thoroughly removed without interference with the anterior wall. The cavity is packed with gauze saturated with the trinitrophenol solution for a few minutes to loosen the membrane, regardless of its thickness. Frequently, when fibrosis is marked, the membrane may be removed *en masse*. In any event, it may be scrubbed out with small gauze balls soaked in the solution and used as a curette; the sharp curette has no

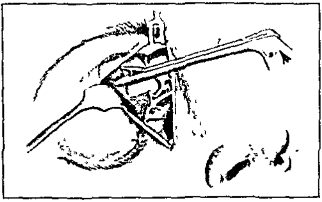


Fig 2588.—The floor of the frontal sinus is removed with a punch forceps

(*Ferris Smith.*)

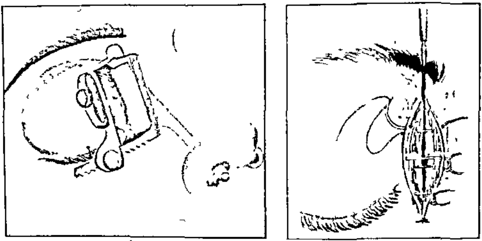
place in this procedure. Inspection with a mirror should now reveal scrupulously clean bony walls.

"Finally, a proper drainage duct for the unobliterated portion of the sinus must be maintained. The attempt to accomplish this with obturators and long-continued sounding is futile in most instances. A flat, inflatable rubber pad is introduced into the defect left by removal of the lamina papyracea, and is covered to a point above and below the opening in the bone with a Thiersch graft taken from the arm or thigh (see figs. 2590B and 2589A). The pad is smeared with petrolatum, and the skin, with its raw surface external, is wrapped around its lateral and anterior walls. The pad is then inflated to produce a gentle pressure against the periorbita. The graft adheres to the underlying muscle and periorbita, and prevents the adhesion of these structures to the margins of the bone.

"Deep horse-hair sutures are then passed through the skin and muscle to approximate the soft parts to the graft (see fig. 2589B). These are removed on the third day, and the skin is supported by a gauze strip applied with collodion. No intra-nasal dressings are applied, nor is the

wound disturbed in any way until the fifth day. At this time secretion is removed by gentle suction which avoids the denuded areas of bone. Only a few days of such care are required until the patient is discharged and permitted to complete his own management.

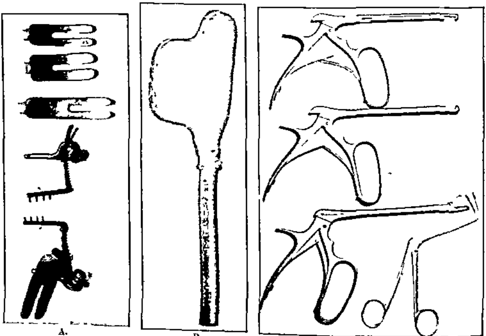
"A few specially designed instruments, in addition to the Hajek and



A B

Fig 2589—A shows a skin graft supported by an inflatable rubber pad to form an epithelialised frontal duct, B, closure of the periosteum, muscle and skin with vertical mattress sutures of horse hair

(*Ferris-Smith*)



A. B. C.

Fig. 2590—A shows right and left self retaining orbital retractors with interchangeable blades of two sizes; B, flat inflatable rubber pad for the approximation of skin graft to the periorbita; C, heavy punch forceps for removal of bone, and a sponge carrier for use in the frontal sinus.

(*Ferris-Smith*)

Grunwald punch forceps and the bayonet-shaped rongeurs found in a rhinological surgeon's equipment, are sufficient for the accomplishment of this operation. Self-retaining retractors (fig. 2590A) designed for the right and left sides, and fitted with two widths and lengths of slotted blades, facilitate the work. Such retractors make it unnecessary to have an assistant in performing the operation, and prevent the trauma resulting from the frequent adjustment of hand retractors.

"Specially designed heavy punch forceps, of a proper length to permit use in the sphenoid cavity (fig. 2590C), render the removal of the heavy bone of the nasal process of the superior maxilla simple, and unannoying to the patient. Chisels and mallets find no place in this technique. These forceps readily remove the anterior wall of the sphenoid sinus regardless of its condition. The heavy Grunwald type of punch forceps is useful in removing the floor of the sphenoid sinus. The sponge-carrying forceps (fig. 2590C) are designed for the clearing of the high anterior portion of the frontal sinus. Small gauze balls soaked in the trinitrophenol solution are employed for scrubbing, in place of the usual curettage."

The discussion which followed the lecture demonstrated the great interest evinced in this operation, and from the discussion the following main facts emerged :

(1) That in Great Britain it was doubtful whether patients would submit to such an extensive operation unless a general anæsthetic were administered.

(2) That this operation should in the main be reserved for those cases in which simpler measures had failed to afford relief.

(3) That an essential part of any operation for the cure of chronic frontal sinusitis is the preservation of the patency of the new fronto-nasal duct by means of a skin graft.

(4) That there was marked divergence of opinion as to the necessity for complete removal of the mucous membrane of the paranasal sinuses.

(5) That a considerable number of "die-hard" supporters of intra-nasal operations still survive.

CHAPTER IX

Neoplasms of the Nose and Paranasal Sinuses

A. Benign Growths

These are comparatively rarely found in the nasal or paranasal cavities, but a number of different forms have been recorded.

Papillomata. Two varieties of papilloma occur in the nose:

(1) Soft; usually growing from the skin of the vestibule.
(2) Hard; springing from the septum, or, more rarely, from the inferior or middle turbinal. They have also been reported as arising from the ethmoidal, frontal and sphenoidal sinuses.

It is important to distinguish between the true papilloma and the papillary hypertrophy which is so frequently seen at the posterior end of the inferior turbinal.

Treatment. They may be removed with a snare, and the base then cauterised with the electro-cautery. Recurrence is common, and is probably due to implantation at the time of operation. Recurrence may be prevented by the application of radium to the base after removal of the papilloma.

Osteomata. Such growths are of two varieties, the hard and the soft. The frontal sinus is most commonly affected, but the ethmoid, sphenoid, or antrum may be primarily involved. These tumours are usually pedunculated, so that even the ivory-hard osteoma may be removed *en masse.* An osteoma may attain such size as to cause marked facial disfigurement, and lead to severe nasal obstruction. Exophthalmos may result, and neuralgia is frequently complained of. An inspection of the nasal cavity may reveal the presence of polypi which conceal the osteoma. In certain cases erosion of the cribriform plate, or of the posterior wall of the frontal sinus, may result in meningitis.

Diagnosis may be assisted by a good skiagram, which will show the outline of the bony growth.

Treatment consists of removal through an external incision. A frontal osteoma may be dealt with by removal of the anterior plate of the frontal sinus, an antral osteoma by a Caldwell-Luc operation, whilst lateral rhinotomy will give access to an ethmoidal osteoma.

Chondromata and *Osteo-chondromata* are very rarely found. If present, they expand slowly, and closely resemble osteomata.

Fibromata of the nasal cavity are not common. Small ones may spring from the septum, or from the roof or outer wall of the nose; they tend to bleed profusely, and to cause some degree of nasal obstruction. Removal with a snare, and the application of the electro-cautery to the base, will usually effect a cure.

Angiomata. The so-called "bleeding polypus of the septum" is an angioma, and is usually found near Kisselbach's area, but may be present further back on the septum, or on the floor or outer wall of the nose. Angiomata are dark red in colour, vary in size from a pea to a marble, and cause nasal obstruction and severe epistaxis. To remove them the mucosa and perichondrium of their base must be dissected from the bone, and the raw surface treated with the electro-cautery.

Rarer benign growths are adenomata, lipomata, lymphangiomata, congenital gliomata, and certain forms of mixed tumours.

B. Malignant Growths

These are comparatively more common than benign tumours in the nose and paranasal sinuses. It was formerly thought that sarcomata occurred much more frequently than carcinomata, but it is probable that this misapprehension was due to the fact that many so-called sarcomata were in reality atypical round-celled carcinomata or endotheliomata. Modern authorities consider that of these malignant neoplasms about 60 per cent are carcinomata, 30 per cent sarcomata, and 10 per cent endotheliomata. The malignancy of these tumours varies enormously, and their response to treatment naturally depends upon the degree of malignancy.

Of the accessory sinuses the antra and the ethmoidal cells are most commonly affected, but occasionally the sphenoid and frontal sinuses are the primary seats of the growth. Malignant neoplasms may also originate in the floor of the nose, on the septum, or from the turbinals.

Carcinomata are usually of the squamous-celled variety, but the basal-celled form is also found. Carcinomata are rare in patients under forty years of age.

The squamous-celled forms are locally very malignant, and tend to invade neighbouring structures. Metastases usually appear first in the cervical glands, but in some cases this glandular involvement is a late feature of the disease. If, however, the growth is incompletely removed by operation, rapid recurrence takes place, and the glands soon become

involved. The basal-celled carcinomata are much less malignant, and respond more readily to treatment by irradiation.

Sarcomata may appear at any age, and may be of many types and of varying degrees of malignancy. Lympho-sarcomata and the round- and spindle-celled types are the most malignant, whilst fibro-sarcomata are the least malignant of all. Chondro-, myxo-, and osteo-sarcomata vary greatly in their degree of malignancy.

Endotheliomata may remain encapsulated for many years, and glandular involvement is late in appearing. They show, however, a marked tendency to recur after simple removal, and in these circumstances dissemination to the glands occurs more rapidly.

Malignant Growths of the Maxillary Antrum.

It is unfortunate that these tumours may exist for a long time before definite symptoms of trouble arise. Pain is seldom an early feature, and nasal obstruction, accompanied perhaps by a thin blood-stained discharge, may be all that is complained of by the patient. Later he suffers from pain in the alveolus, and finally there may be swelling of the cheek, bulging of the naso-antral wall into the nose, and exophthalmos due to the upward growth of the tumour. The squamous-celled growths frequently invade the hard palate, and the writer has recently seen a case in which this was the first symptom.

Trans-illumination usually shows opacity of the antrum, but a skiagram may not be diagnostic until bony erosion has occurred. Antral puncture and suction will often reveal the presence of blood-stained fluid in the antrum, and this should be regarded as a very suspicious sign.

Malignant Growths of the Ethmoid.

These usually originate in the posterior cells, but may arise anteriorly in the lachrymal region. Epistaxis and nasal obstruction are early symptoms, and neuralgic pains and purulent nasal discharge are not uncommon. Epiphora and exophthalmos may ensue as the tumour increases in size, but glandular involvement is a late feature. On examination of the nose, pus is seen in the nasal cavity, and polypi, which bleed easily, may almost fill one or both sides of the nose. In the final stages the growth may invade the base of the skull and cause death from meningitis.

Primary growths of the sphenoid are rarely found, but invasion may result from the extension of a tumour of the posterior ethmoidal cells.

The frontal sinus is rarely primarily involved, but growths in the sinus may erode either the anterior or posterior wall, and thus invade the neighbouring structures.

Prognosis is by no means so grave as it was some years ago; the modern combination of surgery, diathermy and irradiation has rendered the outlook much more hopeful. Harmer maintains that no surgeon should undertake the treatment of these cases unless he has all three methods at his disposal. It must, however, be remembered that radium and deep X-ray therapy are not always available, and some description of the purely surgical measures must be given.

Operative Treatment of Ethmoidal Growths.

Intra-nasal attack is useless, for it is essential that the whole of the growth should be visible before its removal is attempted.

The ingenious sub-labial operation of Rouge leaves no visible scar, but it gives insufficient access, and the technique will not be described here.

Moure's operation of lateral rhinotomy has given many excellent results, particularly in those cases where invasion of the neighbouring structures has not occurred.

After preliminary packing of the nose with gauze wrung out of cocaine and adrenalin solution, an intra-tracheal general anæsthetic is administered, and the naso-pharynx and pharynx are well packed off. The incision originally advocated was one starting at the inner end of the eyebrow and passing down along the side of the nose as far as the ala; if more room was required, a second incision was made from near the upper end of the first, and prolonged outwards along the lower orbital margin to reach the malar eminence. The scar of this latter incision, however, is followed by persistent puffiness of the lower lid, and in order to avoid this Trotter suggested the incision shown in figure 2591. The lower eyelid is everted and the incision enters the palpebral conjunctiva just external to the punctum lachrymale, is continued horizontally outwards inside the lid, and is then directed downwards and outwards from the external canthus on to the malar eminence.

The ala and side of the nose are next detached with an elevator and retracted towards the mid-line, whilst the soft tissues of the cheek are similarly raised and drawn downwards and outwards. In this way the nasal bone, the nasal process of the frontal bone, the ascending process of the superior maxilla, and the canine fossa can be exposed. The lachrymal sac should be defined and carefully retracted out of harm's way, lest subsequent epiphora develop.

A chisel cut is then made through the superior maxilla from the lower orbital margin to the edge of the pyriform fossa. This cut passes obliquely downwards and inwards just above and internal to the infra-orbital foramen. A second chisel cut passes vertically upwards just

Operative Treatment of Growths of the Maxillary Antrum.

The combination of surgery, diathermy and irradiation has now almost entirely superseded the treatment of these growths by removal of the upper jaw, but it is felt that a description of the latter operation must be given.

Removal of the Upper Jaw.

An intra-tracheal anæsthetic is administered, and the naso-pharynx and pharynx are securely packed off with gauze. In the majority of cases the preliminary ligature or temporary ligature of the external carotid artery is desirable. The incision suggested by Trotter (fig. 2592) is made, extending from the malar eminence across the everted lower lid

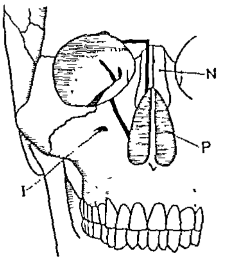


Fig 2593.—Diagram showing incisions in bone for Moure's operation of lateral rhinotomy.

N Nasal bone
I Infra-orbital foramen
P Pyriform aperture

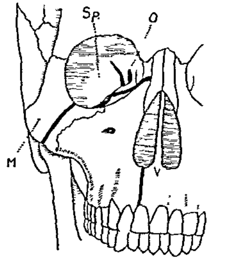


Fig 2594.—Diagram showing the incisions in the bone required for removal of the superior maxilla

O Optic foramen.
Sp. Spheno-maxillary fissure
M Malar bone

to the nose, and then passing down along the side of the nose, round the ala, and through the upper lip near its centre. The flaps thus marked out are reflected from the nose and cheek respectively, and are protected by gauze wrung out of hot saline. In this way the whole of the anterior surface of the superior maxilla is exposed. The periosteum of the orbital floor is then elevated and pushed backwards; care must be taken to protect the eyeball from injury during this stage and the remainder of the operation.

The bone is next divided as shown in figure 2594.

(1) The line of incision is marked out with a scalpel just behind the junction of the superior maxilla and the malar bone, and a deep groove is made in this line with a saw. The division

to one side of the articulation between the two nasal bones, and from its upper extremity a further cut is made horizontally outwards until it reaches the orbital margin (fig. 2593). The piece of bone thus isolated is removed with strong forceps, and includes the antro-nasal wall and the inferior turbinal. The mass of the growth will be thus brought into view, and may be removed with forceps and a Volkmann spoon. If the tumour has infiltrated the neighbouring structures it may be followed backwards to the sphenoid, outwards into the orbit, or downwards to the antrum. Where a posterior growth has to be dealt with it is essential to protect the cribriform plate during its removal, and Moure suggests that a gouge be passed backwards parallel to the cribriform plate

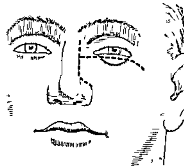


Fig 2591.—Incision for Moure's operation of lateral rhinotomy showing Trotter's incision through the conjunctiva of the lower eyelid. The incisions are indicated by the dotted lines

Fig 2592.—Trotter's incision for complete removal of upper jaw, indicated by dotted line.

until it reaches the anterior sphenoidal wall, and be held in position by an assistant whilst the surgeon is at work.

Bleeding is usually profuse, but can generally be controlled by swab pressure; if the whole of the growth has been removed, the hæmorrhage tends to stop spontaneously and it is rarely necessary to ligate the external carotid artery. It is desirable not to leave the cavity tightly packed at the conclusion of the operation, but a strip of ribbon gauze may be lightly inserted with one end projecting from the nostril. The skin incisions are carefully approximated with horse-hair sutures.

The gauze strip is removed in 24–48 hours, and a mild nasal wash is then used until the discharge ceases.

It is the practice of many surgeons to insert radium at the end of this operation; radium tubes are enclosed in loose gauze packing, and allowed to remain in position until an adequate dose has been given. It may also be of advantage to give a preliminary small dose of X-rays in order to produce some shrinking of the tumour prior to the operation.

Operative Treatment of Growths of the Maxillary Antrum.

The combination of surgery, diathermy and irradiation has now almost entirely superseded the treatment of these growths by removal of the upper jaw, but it is felt that a description of the latter operation must be given.

Removal of the Upper Jaw.

An intra-tracheal anæsthetic is administered, and the naso-pharynx and pharynx are securely packed off with gauze. In the majority of cases the preliminary ligature or temporary ligature of the external carotid artery is desirable. The incision suggested by Trotter (fig. 2592) is made, extending from the malar eminence across the everted lower lid

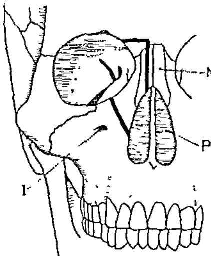


Fig 2593.—DIAGRAM SHOWING INCISIONS IN BONE FOR MOURE'S OPERATION OF LATERAL RHINOTOMY

N. Nasal bone
I Infra orbital foramen
P Pyriform aperture

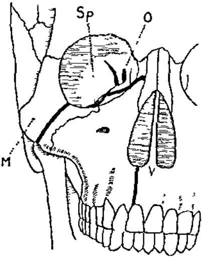


Fig 2594.—DIAGRAM SHOWING THE INCISIONS IN THE BONE REQUIRED FOR REMOVAL OF THE SUPERIOR MAXILLA

O Optic foramen
Sp *Spheno maxillary fissure*
M Malar bone

to the nose, and then passing down along the side of the nose, round the ala, and through the upper lip near its centre. The flaps thus marked out are reflected from the nose and cheek respectively, and are protected by gauze wrung out of hot saline. In this way the whole of the anterior surface of the superior maxilla is exposed. The periosteum of the orbital floor is then elevated and pushed backwards; care must be taken to protect the eyeball from injury during this stage and the remainder of the operation.

The bone is next divided as shown in figure 2594.

(1) The line of incision is marked out with a scalpel just behind the junction of the superior maxilla and the malar bone, and a deep groove is made in this line with a saw. The division

is completed with strong bone-cutting forceps, care being taken to prevent damage to the orbital contents.

(2) The nasal process of the superior maxilla is now divided by making a groove with a saw, and completing the section with bone-cutting forceps Care should be exercised to avoid splintering the bone

(3) If the upper teeth have not already been removed, the lateral or central upper incisor is now extracted, and the mouth is held widely open by means of a gag. An incision is made with a scalpel or diathermy knife from the lower margin of the pyriform aperture down the front of the alveolus and is continued backwards in the mid-line of the hard palate as far as its junction with the soft palate. The incision is then carried laterally from this point to reach the alveolar margin just behind the last molar tooth. The soft palate is detached with blunt-pointed scissors, and pushed backwards so that it may be preserved when the maxilla has been removed. The bony incisions are deepened with a saw, and an osteotome is then inserted into the grooves in order to loosen the bone. The section of the alveolus and hard palate may be completed with bone-cutting forceps, and the whole maxilla grasped in lion-forceps and detached by rocking and wrenching movements. Some difficulty may be experienced in the region of the pterygoid and palatine processes, but the detachment will be facilitated by the introduction of curved bone-cutting forceps behind the tuberosity of the maxilla.

When the maxilla has been removed a careful search is made for any remaining areas of growth, which may be treated with diathermy. The bleeding is arrested by pressure with swabs, but plugging of the cavity should be avoided if possible. The skin edges are next brought together and carefully sutured with horse-hair, particular attention being paid to the approximation at the muco-cutaneous junction of the lip. Catgut should be used to close the incision in the mucous surface of the lip.

After-Treatment.

The patient should be well propped up, and his mouth kept as clean as possible by the use of frequent mouth-washes. For the first few days he must be fed with nutrient enemata, or by means of a small œsophageal tube passed through the sound nostril. At a later date he can wear a well-fitting dental plate, and thus eat his food in comfort. The patient should be encouraged to sit up in a chair as soon as possible in order to avoid post-operative pulmonary complications.

Disadvantages of the Operation.

The main disadvantage of this operation is the disfiguring deformity which follows, and if the orbital floor has had to be removed the eyeball will drop downwards, and an unhealthy condition of the eye itself may ensue.

Damage to the lachrymal duct frequently leads to persistent epiphora, but the œdema of the lower lid which followed the performance of the original operation may be avoided if Trotter's incision is used.

In certain cases a fistula appears in the cheek, and will necessitate the wearing of some form of artificial cheek.

When radium is available it is doubtful whether surgical removal of the upper jaw is a justifiable operation. Harmer has treated many patients at St. Bartholomew's and Mount Vernon Hospital by a technique which combines surgery, diathermy and irradiation, and has obtained some excellent results. The principle of this operation is an approach to the growth through the hard palate, as a result of which a permanent palatal opening remains. This technique offers the following advantages :

(1) It gives adequate access for treatment.
(2) It provides efficient and permanent drainage.
(3) It enables constant inspection of the cavity to be made, and thus permits of the recognition of any areas of disease which may have been overlooked, or of early recurrences.
(4) It causes no deformity of the face.

Technique of Harmer's Operation.

An intra-tracheal anæsthetic is administered, and the pharynx is securely packed off to prevent the entrance of blood and discharge into the glottis. Any septic teeth should be extracted, though it is preferable to clear up all dental sepsis beforehand. With a diathermy knife an incision is made, as in figure 2595, to include the alveolus and teeth on the affected side, and the whole of the hard palate of that side.

It is important to preserve the soft palate in order to facilitate the wearing of a dental plate later on ; even if the growth has invaded the soft palate the disease may be eradicated by surface irradiation or by interstitial needling. The area thus marked out by the incision is freed by means of a chisel and mallet, and the hard palate and alveolus are removed with strong forceps. The resultant aperture gives a good exposure of the antrum and nasal fossa, and the growth may be followed up into the ethmoidal or sphenoidal regions. If the growth be

exuberant it is advisable now to destroy as much of it as possible by diathermy (fig. 2596). In the case of very malignant cellular tumours, however, unnecessary interference with the growth is inadvisable, and it is safer to trust to irradiation alone after the palatal opening has been made.

Ribbon gauze soaked in flavine is next loosely packed into the cavity, and is left in position for four to five days. Some surgeons prefer to commence irradiation at once, and insert radium tubes with the packing: but Harmer advises waiting for a few days, and then applying slow but prolonged radiation by means of radium needles held in position on the upper surface of a specially prepared dental plate. This plate consists of two parts: the upper is made of soft stent which is moulded to fit the cavity accurately: the lower is of vulcanite

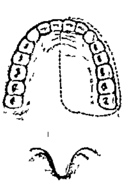


Fig 2595.

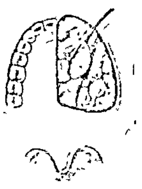


Fig 2596.

Fig 2595.—Incision for the removal of the hard palate.

Fig 2596.—Removal of tumour by diathermy.

(*By kind permission of Mr. Douglas Harmer.*)

which contains a layer of lead to protect the mouth and tongue from irradiation. Upon the surface of the upper part are placed the radium needles, so that they may lie close to the areas which are most affected by the growth; these needles are covered by a thin layer of stent to render the upper surface of the denture smooth. Needles of varying length are employed; they should have a filtration of at least 0.8 mm. of platinum to prevent too severe a reaction, and their total radium content should be from 15 to 20 milligrammes. A skiagram showing the plate and needles in position is to be found in figure 2597. The plate is first worn for two hours night and morning, and later the daily period is increased until a total dose of 1500 to 2000 milligramme-hours has been given. At the end of this time the cavity should be lined with a thick yellow film, and the growth should have shrunk greatly or even disappeared. If, during this treatment, inspection shows that the growth in one part of the cavity is not shrinking, the position of the needles in the stent may be changed so as to increase the irradiation

in that area. The cavity may be kept clean by frequent mouth-washes, or by gentle irrigation through a cannula.

Where the growth is limited to the antrum a complete cure may be expected, but if it has invaded the ethmoidal or orbital regions the eradication of the disease is a much more difficult and uncertain task. In such cases it may be necessary to supplement the treatment by the insertion of radium needles through the skin, but partial or complete removal of the upper jaw is seldom justified.

When complete destruction of the growth has been effected the cavity becomes lined with a smooth membrane, and the palatal opening may then be closed with a snugly-fitting dental plate. The palatal

Fig 2307.—DENTAL PLATE MOULDED TO FIT THE CAVITY IN THE UPPER JAW AND CONTAINING RADIUM NEEDLES. (*By kind permission of Mr Douglas Harmer.*)

opening allows of such free drainage that crusting and discharge seldom occur, and it also enables constant inspection of the cavity to be made. The combined use of surgery, diathermy and irradiation does not appear to cause undue bony necrosis, nor has Harmer encountered any cases of acute spreading osteitis in his series. Grave complications are rare, but the sight of the eye may be lost, or a cataract may later develop.

The writer has seen many excellent results after this treatment has been carried out at Mount Vernon Hospital. Unfortunately many patients are seen only when the disease is in a very advanced state, or when previous surgical measures have failed to arrest it. In such cases it is often impossible to effect a cure, but irradiation with radium or X-rays, or both, will frequently arrest the progress of the disease, relieve pain and hæmorrhage, and prolong life.

The lesson to be learnt is that early diagnosis of malignant neoplasms of the sinuses is of paramount importance; only thus can prospects of complete cure be realised.

Ohngren employs a technique consisting of wide excision of the growth by diathermy, and uses a special diathermy apparatus for the purpose. He maintains that the risk of subsequent deformity must not deter the surgeon from attempting to excise all the affected tissue, and that, if necessary, plastic operations for cosmetic purposes should later be performed. After the growth has been excised he inserts radium, and although this appears to increase the frequency of post-operative intra-cranial complications he claims that the results obtained by electro-coagulation plus radium are greatly superior to those obtained by diathermy alone. Ohngren also advises the pre-operative use of deep X-ray therapy.

Treatment by Irradiation without External Operation.

This may be the method of choice for the treatment of the very malignant round- and spindle-celled sarcomata; in these cases surgery is often dangerous, but the tumours appear to be extremely sensitive to irradiation, which may bring about their complete disappearance. Irradiation is also of great service in the palliative treatment of inoperable carcinomata. If the necessary apparatus is available, a full course of deep X-rays is probably the most effective method of treatment, but owing to the difficulty of delivering an adequate tissue dose by superficial irradiation alone it is usually necessary to employ radium needles as an ancillary aid.

It is certain that the modern methods of treatment of malignant neoplasms of the paranasal sinuses have rendered the prognosis much more hopeful, and the gradual improvement of technique will doubtless lead to even better results.

CHAPTER X

Neoplasms of the Naso-Pharynx

Benign Growths

Of these the naso-pharyngeal fibroma is by far the most common, and although microscopically innocent it is clinically malignant. It tends to increase slowly in size, to invade the neighbouring structures, and to recur after local removal. It usually develops between the tenth and fifteenth years of life, and grows until about the twenty-fifth year, after which time degeneration tends to occur.

Pathologically it consists of fibrous tissue with a preponderance of blood-vessels but very few cells. There is no true capsule, but the surface of the tumour is covered with a thin layer of mucous membrane.

When viewed with a post-nasal mirror such a growth presents a smooth, rounded appearance, and varies in colour from pink to dark red. On palpation it is firm and almost immovable, and is found to be attached by its base to the vault of the naso-pharynx. As it grows it becomes coarsely lobulated, and may press the soft palate forwards and be visible in the pharynx; prolongation of the growth forward into the nose may produce a "frog-face" deformity, whilst absorption of bone may lead to involvement of the orbit or the base of the skull.

The first symptoms are those of nasal obstruction, but as the fibroma grows it may interfere with deglutition or respiration, and cause some degree of deafness from blocking of the Eustachian orifice. There is a marked tendency to hæmorrhage from the nose or naso-pharynx, and in the later stages symptoms of meningitis may appear. Glandular involvement is rare unless there is coexistent sepsis.

Diagnosis. From a choanal polypus the diagnosis is made by the appearance and consistency of the fibroma, and by the fact that the latter is attached to the naso-pharyngeal vault by a broad base.

A gumma in the naso-pharynx may at first resemble a fibroma, but it soon breaks down and presents the typical wash-leather crater in its centre.

From a fibro-sarcoma the diagnosis may be impossible without microscopical examination.

Prognosis is bad unless removal is feasible, and even then a recurrence is probable. This tendency to recurrence usually ceases after the

age of twenty-five, and if the growth can be kept in check until that age the outlook is hopeful. The use of radium and diathermy in the treatment of these growths has proved of great value, and the results have been immeasurably superior to those obtained by earlier surgical methods.

The choice of operation varies according to the size and accessibility of the growth; if it is confined to the naso-pharynx it may be removed through the mouth, but if it has invaded the nose and paranasal sinuses it may be necessary to perform partial excision of the upper jaw in order to expose the growth. It must be remembered that hæmorrhage is usually very severe, and temporary control of the external carotids by means of Crile's clamps may be required.

Removal of the tumour through the mouth is carried out thus:

An intra-tracheal anæsthetic is administered and the hypo-pharynx packed with gauze. The patient's head is extended over the end of the table, and a Boyle-Davis gag inserted to keep the mouth widely open. With the help of a headlight a good view of the parts is obtained, and the soft palate is firmly grasped with forceps and split along the mid-line with a scalpel. A silk suture is passed through the posterior part of both the cut edges, and each half of the soft palate is then pulled forwards and outwards to expose the growth. If the tumour is so large that its basal attachments cannot be defined, it may be necessary to remove a portion of the hard palate and the posterior part of the bony nasal septum. When the growth has been fully exposed, an incision is made with a diathermy knife in the healthy mucous membrane which surrounds the base of the fibroma; this incision is carried down to the bone. The area thus marked out is separated from the subjacent bone with a periosteal elevator, and the tumour is then removed *en masse.* Hæmorrhage is controlled by swab pressure, diathermy, or ligation of the vessels, and the two halves of the soft palate are carefully approximated by catgut sutures. The packing is removed from the hypo-pharynx and the endotracheal tube is withdrawn; if, however, there is much oozing this tube may be left in position until the patient has fully recovered consciousness.

It must be admitted that, in the past, attempts to remove these growths by surgical measures often ended in tragedy, and numerous deaths occurred as a result of uncontrollable hæmorrhage or from the severe shock which followed the operation. The modern tendency is to treat fibromata of the naso-pharynx by X-rays or radium irradiation.

Malignant Growths

Primary malignant disease of the naso-pharynx is uncommon, but endotheliomata, sarcomata and carcinomata do occur. The naso-pharynx may also be secondarily involved by growths originating in the nose, antrum, orbit, pharynx, mouth or tonsils.

The symptoms are similar to those of a naso-pharyngeal fibroma, but the sarcomata in particular tend to grow very rapidly, and hæmorrhage and offensive discharge are earlier symptoms. Except in the case of the lympho-sarcomata, glandular enlargement is comparatively rare.

Carcinoma is uncommon, but if present it shows the typical appearance of an ulcerated mass with everted edges, and is craggy on palpation. Carcinomata tend to spring from the lateral wall of the naso-pharynx, and to invade the Eustachian orifice and cause some degree of deafness, otalgia, and pain in the mastoid region. Glandular involvement occurs early, and may be quite disproportionate to the size of the primary growth. Severe neuralgia is sometimes complained of, and the growth may press on the nerves emerging from the jugular foramen and produce Jackson's syndrome (paralysis of the side of the palate, tongue, pharynx and larynx, and of the homolateral trapezius and sterno-mastoid muscles).

Diagnosis from a naso-pharyngeal fibroma may be difficult, especially in the case of a sarcoma or an endothelioma. A small carcinoma in the naso-pharynx may be very hard to detect, but, if there is severe unexplained facial neuralgia or pain in the ear or eye, a naso-pharyngeal carcinoma should be suspected, and a careful post-nasal examination made.

Prognosis is extremely grave, and the disease cannot be cured by purely surgical measures. Treatment by irradiation holds out the only prospect of success, and although results have so far been rather disappointing it is probable that improved technique will enhance the value of such treatment.

CHAPTER XI

Spreading Osteomyelitis of the Skull

This occurs mainly after operations upon the frontal, ethmoidal or maxillary sinuses, but has been recorded in a few instances after dental or mastoid operations. It is a most serious complication, and in the great majority of cases it proves fatal.

The route favoured by the infection in the bones of the face seems to be towards the frontal bone and the vault of the skull. It appears to avoid the bony roof of the nose and the orbit in the early stages of the disease, otherwise septic meningitis would develop earlier.

von Eicken states that his studies show that large frontal sinuses are for the most part surrounded by a well-developed diploë, especially upwards and laterally. Should the frontal sinus extend far outwards, diploëtic spaces are found in the zygomatic process of the frontal bone. It has long been known that the diploëtic veins of Breschet are most irregular in course and situation and that they do not respect the lines of the sutures. In 1924 the Polish anatomist Wischnowski found that in this region there is a vein so constantly present that he called it the "norma temporalis," and von Eicken, by means of skiagrams in living patients, has confirmed this constancy of incidence. He considers that it is important for rhinologists to bear in mind the presence of this vein which must be thoroughly dealt with during any operation for acute spreading osteomyelitis of the frontal bone.

McKenzie states that in treatment the practical point to note is that drainage of itself is insufficient to arrest the disease, and that the surgeon must erect his barriers and cut his trenches well ahead of the apparent limits of the disease.

He also advises the intravenous injection of colloidal silver, which should be pushed to the limit of tolerance. It appears to be a remedy of special value in this disease, and if given as soon as the osteomyelitis appears it may be expected to prevent widespread necrosis.

Nasal and facial osteomyelitis should be treated by free opening of any abscesses, and the wide removal of any denuded bone. This may necessitate the production of marked facial deformity, but the gravity of the disease is such that cosmetic considerations must occupy a

secondary place. In view of the tendency manifested by the disease *to spread upwards into the frontal bone, an effort must be made to* interpose an effective barrier to such spread. For this purpose a transverse incision should be made across the root of the nose, and a breach of continuity made by gouge or cutting-forceps between the nasal and frontal bones.

When the frontal bone is involved, McKenzie advised that the surgeon should work from the healthy towards the diseased area, and that the first step should be the cutting of a trench in the upper part of the frontal region.

McKenzie's technique is as follows:

A curved incision with its convexity upwards is made from one

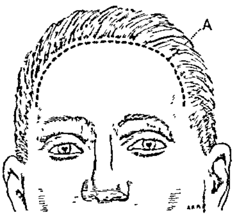


Fig 2598.—A. Line of incision in forehead for treatment of acute spreading osteomyelitis of frontal bone. (*McKenzie.*)

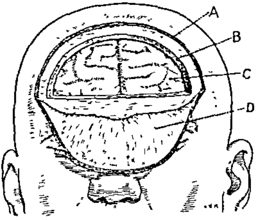


Fig 2599.—Diagram showing removal of bone and exposure of dura

A. Cut edge of soft tissues of forehead.
B. Cut edge of frontal bone.
C. Dura over frontal lobe.
D. Forehead flap pulled down over face.

temporal line, commencing about half an inch above the outer end of the eyebrow, to a corresponding point on the opposite side (fig. 2598). The incision is carried down through the soft tissues of the scalp and pericranium to the bone. The flap thus formed is separated from the bone and drawn downwards. The next step consists in making a curved gutter in the bone in the line of the skin incision; this is effected with a gouge and mallet. The gutter should be rather more than 1 cm. in breadth, and is carried down through the outer table and the diploë. If the diploic veins bleed freely it may be assumed that the bone is not as yet grossly infected; bleeding which does occur may be arrested with Horsley's wax. The gutter is cautiously deepened until the dura is exposed, and as soon as a sufficiently large opening has been made to admit bone forceps these are employed to remove the remainder of the *inner table at the bottom of the gutter.* The forehead flap is next pulled

well down over the face, and further removal of the frontal bone is proceeded with until the supra-orbital margins are reached (see fig. 2599). Any extra-dural collections of pus will thus be exposed, and it is most important to remove the bone freely *in the neighbourhood of such* abscesses. If the osteomyelitis has originated in the frontal sinuses, it will now be necessary to sacrifice the supra-orbital margins in so doing; if, however, the infection has spread from the antrum or ethmoid, one may merely have to drain the frontal sinuses as in Howarth's operation. If the disease is very widespread, it may be necessary to make a vertical incision in the middle line of the forehead flap in order to obtain adequate access to the frontal sinuses. B.I.P.P. is now rubbed on all raw bony edges, and iodoform gauze lightly packed into the wound. The wound may be left open for about ten days, and then closed by secondary suture, or after the bone and dura have been smeared with B.I.P.P. the skin edges may be sutured and drainage ensured by inserting rubber tubes at the extremities of the incision.

PART XXVII

ENDOSCOPIC METHODS IN SURGERY

by

R. J. CANN

ENDOSCOPIC METHODS IN SURGERY

For the purposes of this chapter, endoscopic methods in surgery may be defined as the methods of directly examining the larynx, trachea, bronchi, hypo-pharynx, œsophagus and stomach by means of tubular specula. Except in the case of the more recent gastroscopes, the endoscopic tubes are rigid and, of necessity, straight.

HISTORY OF ENDOSCOPY

The possibility of introducing straight tubes into the œsophagus no doubt arose from the knowledge that sword-swallowers could place the head and neck in such a position that the food passages became approximately a straight line. Once it was established that such positioning was possible in any patient and was not an anatomical trick of the sword-swallower, then œsophagoscopy was assured. The subsequent development to modern methods is mainly due to the ingenuity of surgeons and instrument makers in devising and constructing endoscopic apparatus. The progress of endoscopy is thus intimately bound up with the gradual improvement in instruments.

The first examinations were made by means of tubes slightly conical in shape and about 8 cms. long, introduced into the upper end of the œsophagus, the lumen of the tube then being viewed in a laryngeal mirror. The first direct examination of the œsophagus is said to have been accomplished by *Kussmaul* in 1868, using an urethroscope specially elongated to a length of 43 cms. He was able to see a carcinoma in the thoracic œsophagus, and demonstrated the possibility of introducing rigid tubes into the lowest parts of the œsophagus by using the sword-swallowing position. In 1881 *Mikulicz* designed an œsophagoscope consisting of a tube into which he passed an optical apparatus with proximal illumination. *Einhorn*, in 1902, added an auxiliary tube in the wall of the main tube and in this he inserted a light-carrier to serve as a conducting wire to a small electric lamp which it carried at the distal end of the tube. In 1902 *Killian* first used the œsophagoscope for the removal of a foreign body and showed a large pointed bone removed from the œsophagus of a woman aged 79 years.

In 1828 *Horace Green* of New York conceived the idea of medicating the cavity of the larynx by catheterisation, and thus discovered the law of the tolerance of the larynx to the presence of a foreign body.

In 1885 *Joseph O'Dwyer* introduced his intubation tubes for relief of stenosis of the larynx. These tubes have stood the test of time and are still made after his original model. From the work of Green and O'Dwyer were established the fundamental principles in the evolution of bronchoscopy, namely, the tolerance of the larynx to the presence of a foreign body and the tolerance of the larynx to the continued presence of a foreign body. The principles of œsophagoscopy were soon used for the direct inspection of the larynx, trachea and bronchial tubes. *Kirstein*, in 1895, described the method of direct laryngoscopy, but thought it dangerous to enter the lower part of the trachea. That it was possible to introduce tubes

into the entrances of the main bronchi was demonstrated by *Killian* in 1897. He showed that the large bronchi have thick solid walls supported by cartilage, that they have a high degree of elasticity, and, most important of all, that they are movable. These were great advances in the evolution of bronchoscopy. Killian also demonstrated in 1902 the necessity of having side-openings in the lower end of the bronchoscope to enable the patient to breathe with one lung while the other bronchus was being examined. He was greatly assisted in his work by the inventive genius of *Brunings* who perfected a handle containing a powerful electric light which could be reflected and focused down the bronchoscopic tube. Killian has rightly been styled the father of direct bronchoscopy.

In 1904 *Chevalier Jackson* combined the distal lighting principle of the Einhorn œsophagoscope with the tube of Killian. To Jackson must be allowed the credit for the great impetus given to endoscopy in the early years of this century, for, by his ingenuity in designing instruments for special purposes, by his teaching, and by his insistence on the adequate training of an endoscopist, there has developed this speciality within a speciality.

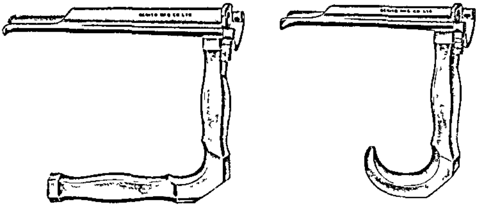
In this country due recognition must be given to the work of *Negus* who has designed a special endoscopic operating table and greatly improved lighting principles for his tubes, the latest of which combines the distal and proximal light in the same tube.

INSTRUMENTS

Endoscopic tubes have been constructed with proximal or distal lighting. The former, with Brunings' lighting apparatus or with the more recent improvements by Haslinger, were especially suitable for diagnostic purposes. The manipulation of instruments through these tubes is not easy, and their free ends tend to be obscured in shadow, especially in the smaller tubes. For accurate endoscopic treatment necessitating the passage of instruments through the tubes, the distal illumination is best and this principle of lighting is the one advocated and designed by Chevalier Jackson. An enlarged view of the field may be obtained by a lens added to the proximal lighting apparatus or by direct-vision telescopes introduced down the tube when distal lighting is used. More recently, Negus has designed a bronchoscope which combines the distal and proximal lighting, and these tubes are here illustrated and described

The usual type of *laryngoscope* is shown in figure 2600. It is made in several sizes for adult, child, and infant The short lower part of the tubular portion slides off in order to allow the removal of the laryngoscope from the mouth after the passage of the bronchoscope through it. The new type of twin electric bulb is used in the illumination of laryngoscopes and œsophagoscopes. The two beams of light are so arranged that they converge and cross each other at the point of emergence from the speculum, that is, at the site of operation.

The *bronchoscope* (figs 2601, 2602 and 2603) is a long hollow brass tube with its distal end slanted and a short vertical handle at the proximal end. The light-carrier is housed in an auxiliary canal in the wall of the tube and its lamp lies in a recess in the bevelled distal end. On the short vertical handle is mounted the proximal light projector which can be moved in or out of position as required. The short side tube fitted into the upper surface of the bronchoscope ends within the lumen near the proximal end and is used for the insufflation of oxygen or anæsthetics. An additional tube may be incorporated into the whole length of the



Adult laryngoscope. *Fig.* 2600. Child laryngoscope.

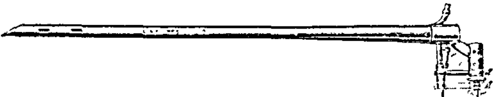


Fig 2601.—Negus' bronchoscope with combined distal and proximal lighting.

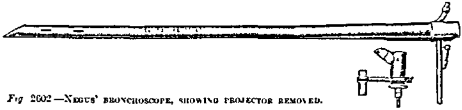


Fig 2602.—Negus' bronchoscope, showing projector removed.

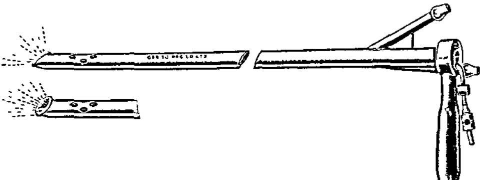


Fig 2603.—Chevalier Jackson's aspirating bronchoscope.

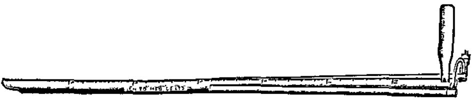


Fig. 2604.—Adult long œsophagoscope.

bronchoscope and is intended for the aspiration of secretions. The additional size to the bronchoscope caused by this aspiration tube makes it a disadvantage in most tubes, and aspiration is best carried out by an independent aspirator. There are small holes in the walls of the distal end of the bronchoscope to allow air to enter from other bronchi when the tube's mouth is inserted into one whose aerating function is impaired.

The *œsophagoscope* (see fig 2604) differs from the bronchoscope in not having lateral breathing holes and in its lighting system, which is by means of twin lamps in the wall of the proximal end of the tube similar to the laryngoscope. A suction tube may be incorporated as in the bronchoscope.

Bronchoscopes and œsophagoscopes are made in varying sizes of diameter and length In figure 2605 and the accompanying tables the measurements of the sizes most commonly used are shown. It was customary to identify the size of an instrument by the diameter of its lumen when deciding upon the proper instrument for a given age of patient. This procedure had serious drawbacks, since it disregarded the external measurements which vary with different patterns of tubes, and in the case of bronchoscopes often resulted in œdema or even trauma of the vocal cords.

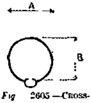


Fig 2605.—Cross-section of bronchoscope tube.

BRONCHOSCOPES

Size	Outside diameter	Inside diameter. "A."	Inside diameter over lamp. "B."	Circumference.	Length.
	mm.	mm.	mm.	mm.	cm.
Adult	11·0	10 0	8·7	35·0	40
Adolescent	9·0	8 0	6·7	29·0	40
Adult aspirating	8 5	7·5	6 2	29 0	40
Child	8 0	7·0	5·7	26·0	30
Child aspirating	7 5	6·5	5·2	26 0	30
Infant	6 0	5 4	4·1	19·5	27·5
Lower bronchus	7 0	6·4	5·1	22 5	45

ŒSOPHAGOSCOPES

Size	Outside diameter.	Inside diameter	Circumference.	Length.
	mm.	mm.	mm.	cm.
Adult long, full lumen	18×20	15·6×17·6	60	45
Adult long, medium lumen	14×16	11 6×13 6	48	45
Adult short	16×18	13·6×15 6	55	35
Child	10×12	8 0×10 0	35	35

The sizes indicated in these tables are those most commonly used.

The simplest and safest source of current is a dry cell. These are provided, three in a box, with separate circuits each having a rheostat. Rubber-covered *cords to plug into the box, and carrying a switch connection for the lamp-carrier,* are the best. All endoscopic tubes are provided with a duplicate lamp-carrier in case a bulb fails during use.

An efficient electric suction apparatus is essential to endoscopy. It should be provided with an ample length of pressure tubing, and between this and the aspirating tube is inserted a further length of rubber tubing and a small glass collecting

Fig 2606.—Swab holder.

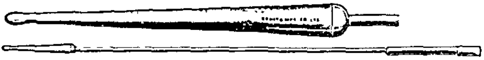


Fig. 2607.—Œsophageal or bronchoscopic dilator.

bottle. This section is sterilised with the instruments and enables the operator to obtain an uncontaminated specimen of the suction products for pathological or *bacteriological examination. Various aspirating tubes are made. The broncho*scopic aspirator may have a straight open end or, for insertion into the subdivisions of the bronchi, a flexible gum elastic end. Œsophageal aspirators are made with lateral eyes to prevent the trauma of the œsophageal mucous membrane which may occur if strong suction is exerted by an open end.

Figures 2606 and 2607 illustrate the Jackson type of bougie made in varying sizes for bronchoscopic and œsophagoscopic dilatation and also a pattern of swabholder. Swabs are made from rectangular pieces of gauze folded so that all edges

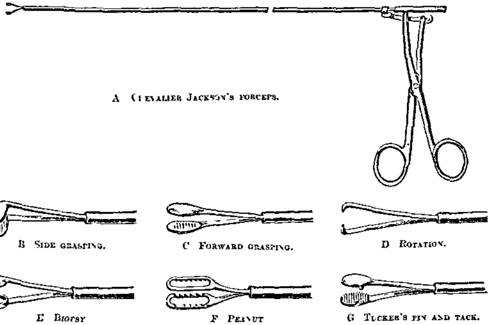


Fig 2608.—Endoscopic forceps for bronchoscopy and œsophagoscopy.

are hidden, and are made in different sizes for different sized tubes. A stock of these should always be ready sterilised and packed into bundles by threading them on to a safety-pin.

Endoscopic forceps are made with a common pattern handle but with a variety of ends. The commoner ends are illustrated in figure 2608. By closure of the handles

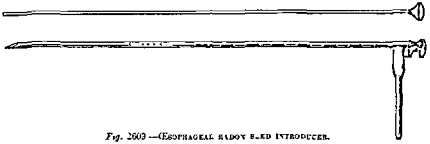


Fig. 2609.—Œsophageal Radon Seed Introducer.

the forceps end is drawn into a cylinder and is so closed. It is important to realise that by this method of closure the working length of the instrument is lessened as it comes into action on the foreign body, and allowance must be made by a progressive insertion of the instrument during closure. A stronger type of forceps is useful for the removal of foreign bodies from the œsophagus.

The use of radium in endoscopy has necessitated the designing of instruments for its introduction. Figure 2609 shows the introducer for radon seeds into the

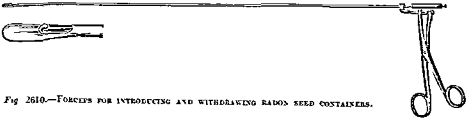


Fig. 2610.—Forceps for introducing and withdrawing radon seed containers.

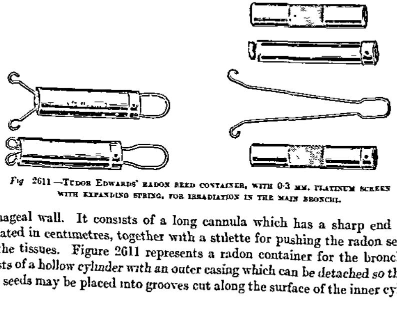


Fig. 2611.—Tudor Edwards' radon seed container, with 0·3 mm. platinum screen with expanding spring, for irradiation in the main bronchi.

œsophageal wall. It consists of a long cannula which has a sharp end and is graduated in centimetres, together with a stilette for pushing the radon seed out into the tissues. Figure 2611 represents a radon container for the bronchi. It consists of a hollow cylinder with an outer casing which can be detached so that the radon seeds may be placed into grooves cut along the surface of the inner cylinder.

A spring with expanding ends serves to anchor the cylinder against the bronchial walls, and a special introducer is provided which draws the spring ends into the cylinder during introduction and removal. These are made in varying sizes according to the diameter of the bronchus to be radiated (fig 2610).

Chevalier Jackson has a trained assistant to hold the patient's head in the correct position during endoscopy, but in this country it is becoming customary to use a special head-rest or table. The Haslinger head-rest or its modification may be attached to any operating table. Negus has designed a special table for endoscopy (figs. 2612 and 2613). The essential in all endoscopies is to maintain the correct position of the patient's head. In the case of laryngoscopy and bronchoscopy it is necessary for the head to be extended on the neck at the occipito-atlantal joint without extension of the neck. In fact, during most of the time the

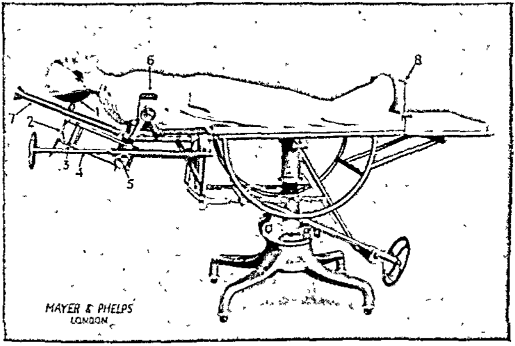


Fig. 2612 —Position for bronchoscopy.

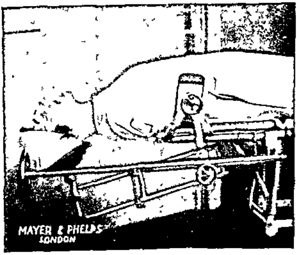


Fig. 2613 —Position for œsophagoscopy

neck is flexed. The special head-rests maintain the extended position of the head while allowing the head to be lowered or raised or moved from side to side.

For the protection of the operator's eyes a face-shield or spectacles must be worn. The face-shield is fitted with a glass plate which can be rotated when one area becomes soiled by the coughing against it of secretion. The glass should be prepared beforehand on each surface with a special grease to prevent smearing from moisture in the patient's or operator's breath.

Enlarged views of the field can be obtained by the use of direct-vision telescopes which are made to fit into the endoscopic tube and provide an upright image. For the inspection of the lumen of the upper lobe bronchi, special retrograde telescopes are made. These all require to be warmed in hot water prior to use in order to prevent misting of the lens.

Many other accessory instruments have been made for special problems in endoscopy, and all illustrate the great skill and ingenuity of the present-day instrument maker.

All endoscopic instruments, with the exception of the lamps and their carriers, may be sterilised by boiling. The lamps are wiped over with surgical spirit, care being taken to see that the actual terminals are not left wet. The rubber-covered electric leads should be placed in the steriliser for two minutes only and care must be taken in the boiling of any gum elastic part. Some workers favour the complete sterilisation of their instruments in formalin vapour.

ŒSOPHAGOSCOPY

Indications for Œsophagoscopy.

(1) The knowledge or suspicion of a foreign body being present in the œsophagus.
(2) The persistence of any abnormal sensation or disturbance of function of the œsophagus.
(3) For the confirmation of radiological findings.
(4) For the purposes of biopsy.
(5) To carry out local treatment.

Contra-Indications to Œsophagoscopy.

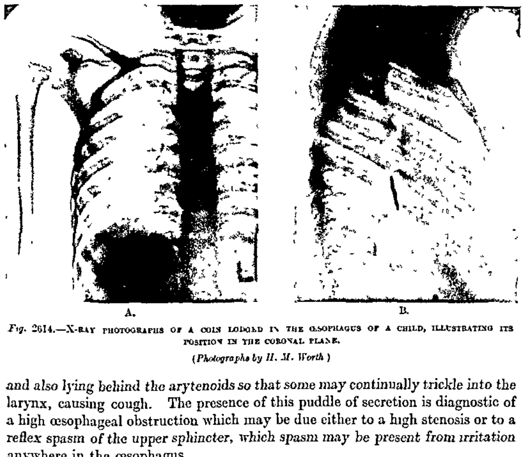
There are no absolute contra-indications to œsophagoscopy for the removal of foreign bodies, though occasionally it may be considered wiser to defer further attempts when a traumatic œsophagitis has developed following previous unsuccessful or unskilled efforts. In such a case the foreign body might be difficult to find, while the chances of further damaging the œsophagus by the passage of a tube would be great.

In general, patients with advanced cardiac or pulmonary disease, aneurysm of the aorta, œsophageal varices from cirrhosis of the liver, or acute œsophagitis, either infective or from swallowing caustics, should not have the œsophagoscope passed. Clearly, each case must be considered on its merits, since what might be an absolute contra-indication in one case might only be a relative contra-indication in another.

Preparation for Œsophagoscopy.

All patients for œsophagoscopy should receive a general medical examination. This is essential in order to exclude any disease which might contra-indicate the proposed endoscopy. It is important, also, that there should be a local examination of mouth, pharynx and larynx, the last mentioned by means of the laryngeal

mirror. Some foreign bodies may not have reached the œsophagus and will be seen lying in the vallecula or pyriform sinus or, in the case of small fish bones, may be impacted in the tonsil or base of the tongue. The presence of paralysis of the pharyngeal muscles may explain a case of dysphagia, or a laryngeal palsy may be an aid in localising an œsophageal lesion. Acute inflammation of the larynx or pharynx might indicate the advisability of delaying an œsophagoscopy until such time as the condition was well when, possibly, the symptoms suggesting the œsophagoscopy would have disappeared also. The passage of the œsophagoscope when any degree of laryngeal œdema is present is distinctly liable to produce an acute laryngeal obstruction, while the existence of an acutely inflamed pharynx greatly increases the tendency to hæmorrhage during an œsophagoscopy. The mirror examination of the larynx may reveal a collection of frothy mucus filling each pyriform sinus



A. B.

Fig. 2614.—X-RAY PHOTOGRAPHS OF A COIN LODGED IN THE ŒSOPHAGUS OF A CHILD, ILLUSTRATING ITS POSITION IN THE CORONAL PLANE.

(Photographs by H. M. Worth)

and also lying behind the arytenoids so that some may continually trickle into the larynx, causing cough. The presence of this puddle of secretion is diagnostic of a high œsophageal obstruction which may be due either to a high stenosis or to a reflex spasm of the upper sphincter, which spasm may be present from irritation anywhere in the œsophagus.

Whenever an œsophagoscopy is indicated, an X-ray examination of the patient should first be made. This should include a screen examination in addition to the taking of films. The skiagrams may thus reveal an aneurysm or a mediastinal mass in addition to the œsophageal abnormality. It is imperative that films should be taken in the lateral as well as in the antero-posterior position, especially in the localisation of foreign bodies. It is important to remember in this respect that a flat foreign body will lie with its greatest diameter in the coronal plane of the body when in the œsophagus, and in the sagittal plane when in the larynx or trachea (fig. 2614). The examination must be made also with and without the

swallowing of a radio-opaque substance. For the diagnosis of œsophageal obstruction the consistency of the swallowed opaque mixture may have to be increased so that it is thick enough to be held up by the obstruction. Further help in this respect may be obtained by examining the patient in the horizontal position as well as in the vertical. Non-opaque foreign bodies may be demonstrated by allowing the patient to swallow opaque capsules which will be arrested on reaching the foreign body. In all cases of suspected foreign body, however, a negative report from the radiologist must not be allowed to outweigh history and symptoms in deciding whether an œsophagoscopy should be carried out. Jackson advocates that the X-ray examination should always include all the structures from the naso-pharynx to the tuberosities of the ischia; otherwise a foreign body may be overlooked or, if one is found, others may be overlooked in cases of multiple foreign bodies.

If œsophagoscopy is contemplated for the purposes of treating the œsophagus, such as the dilatation of strictures or the insertion of radium, then attention must be paid to the cleanliness of the mouth. Some workers advocate rendering the patient edentulous. This is certainly necessary in cases of carcinoma of the œsophagus, in which condition septic teeth are almost constantly found.

A patient with prolonged and advanced œsophageal obstruction will certainly be in bad general condition and it may be advisable to defer œsophagoscopy, even for diagnostic purposes, until the strength of the patient has been improved by feeding via a gastrostomy. Patients with acute œsophageal obstruction may be suffering from water starvation and for this reason are bad subjects for operation or endoscopy. Considerable improvement in their condition may be obtained by the giving of saline per rectum for 24 hours, and if potassium bromide be added to each volume of saline (60 grs. in each pint) it will be found in many cases that the patient will be able to take fluid by mouth again. By this means it should be possible to defer the œsophagoscopy for a few days while the patient's condition improves and while other investigations are being carried out.

In addition, whenever possible, the Wassermann test should be performed.

Anatomy.

The general relations, blood supply and nerve supply of the œsophagus are enumerated on page 3040.

For the purposes of endoscopy it is important to note certain details as to length, size of lumen, direction, and movement of the œsophagus.

Most œsophagoscopes are marked in centimetres of their length, commencing at the distal end. The length of tube introduced can thus be measured against the level of the incisor teeth.

The endoscopic landmarks consist of the upper and lower ends and three intermediate narrowings. The upper end is characterised by the presence of a sphincteric muscle, the crico-pharyngeus, which is a specialised band of the lower fibres of the inferior constrictor muscle. The muscle is attached laterally to the cricoid cartilage and posteriorly in the median posterior raphe. Its contraction pulls the cricoid against the posterior wall of the hypo-pharynx and thus closes the mouth of the œsophagus. This closure is tonic and constant. Opening only takes place as a co-ordinate part of swallowing or vomiting (fig. 2615). The lower end of the œsophagus is characterised by the change from the smooth mucous membrane of the œsophagus to the reddish gastric mucosal folds and by a gush of fluid from

the stomach. This level must not be confused with the diaphragmatic narrowing which is one or two inches above the junction of the œsophagus with the stomach.

The three narrowings of the œsophagus are caused by the aorta and left bronchus which cross it anteriorly, and by the diaphragm which constitutes a lower sphincter.

The aortic narrowing varies in degree, but if the mouth of the œsophagoscope

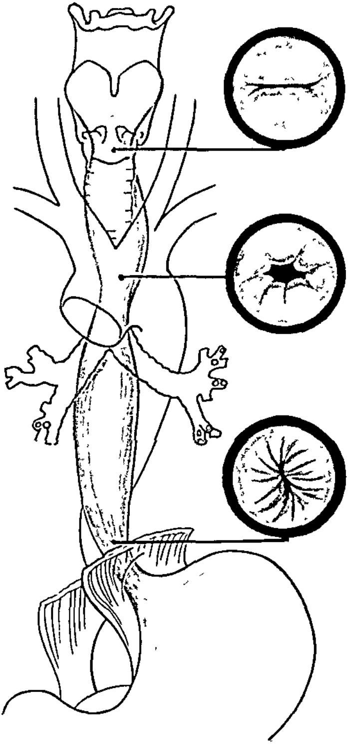


Fig. 2615.—ANATOMY AND ENDOSCOPIC APPEARANCES OF THE ŒSOPHAGUS.
(*Modified after Haslinger*)

be directed against the left anterior wall of the œsophagus, the pulsations of the aorta are markedly felt.

Immediately below this point the left bronchus causes a slight backward displacement of the œsophagus, and the ridge so caused may be prominent in elderly patients with dilatation. The lowest narrowing caused by the diaphragm is often mistaken for the lower end of the œsophagus. Jackson describes the arrangement of the tendinous and muscular structure of the diaphragm as acting on the lower end of the œsophagus in a way similar to a clip on the rubber tube of a laboratory burette. He also describes special bundles of muscle-fibres which extend from the crura of the diaphragm and surround the œsophagus, and which contribute to tonic closure and co-ordinate opening. Keith, however, maintains that a true

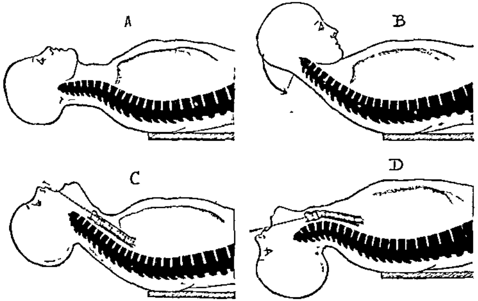


Fig 2616.—To illustrate production of the correct position of the head during endoscopy. A. Patient recumbent B Head and neck flexed C. Head extended at the occipito atlantal joint—correct position. D. Head and neck extended—incorrect position

œsophageal sphincter exists in the wall of the œsophagus at the level of the hiatus of the diaphragm but entirely independent of it.

There is a fourth narrowing, but this is not observable during œsophagoscopy. It is situated at the level of the superior aperture of the thorax and is probably produced by the crowding together of the numerous structures which enter or leave the thorax through this orifice. Its importance lies in the fact that it is the commonest level for the lodgment of foreign bodies.

The œsophagus follows the curves of the cervical and upper thoracic sections of the vertebral column, and so in its upper two-thirds has a decidedly backward direction. Below this it turns gradually forwards to pass through the diaphragm anterior to and to the left of the aorta. In addition, the lower third takes a marked turn to the left. These changes in direction must be borne in mind during the performance of œsophagoscopy as the position of the head and neck must be altered to allow the progressing œsophagoscope to point in the direction of the part of the œsophagus in view.

The movements of the œsophagus consist of the intrinsic ones of involuntary muscular contraction, as in swallowing and regurgitation, and of the extrinsic or transmitted movements. These are the pulsatory movements from the aorta and, lower down, from the heart itself, while the negative intra-thoracic pressure causes the lumen of the thoracic œsophagus to open up during inspiration. It must be remembered that the œsophagus takes part in any shifting of the mediastinum due to respiratory disease.

Anæsthesia for Œsophagoscopy.

Œsophagoscopy may be carried out under general or local anæsthesia. It is possible to pass the œsophagoscope without any anæsthetic at all, but this requires expert skill on the part of the operator and demands the co-operation of the patient to a degree that is unnecessary in most cases. Generally speaking, the beginner will be wise to use general anæsthesia in all cases unless such is contra-indicated by the condition of the patient. As his skill increases he may adopt local anæsthesia. Where spasm of the œsophagus is expected, as in cases of impacted foreign bodies, general anæsthesia is preferable. Young children do not tolerate cocaine and are unlikely to be co-operative, so that it is both safer and kinder to give them a general anæsthetic. The choice of anæsthetic among expert endoscopists varies. In Jackson's Clinic no anæsthetic, local or general, is used for adult œsophagoscopy, while other workers reserve local anæsthesia for those cases only where a general anæsthetic is inadvisable.

When local anæsthesia is adopted, a preliminary hypodermic injection of morphia ($\frac{1}{4}$ to $\frac{1}{3}$ gr. for adults) should be given a half to one hour before operation. This may be combined with atropine sulphate ($\frac{1}{100}$ gr.) to minimise secretions and to obtain further anti-spasmodic effect. Some workers give also scopolamine hydrobromide ($\frac{1}{150}$ to $\frac{1}{100}$ gr.). Immediately before the endoscopy the pharynx is sprayed with a 10 per cent solution of cocaine, after which a few drops may be swallowed, which thus reach the hypo-pharyngeal region. Anæsthesia is not necessary in the lumen of the œsophagus, for this region is insensitive. In young children the appropriate dose of morphia and atropine may be given, but it is safer to omit the cocaine.

In administering a general anæsthetic the preliminary medication and the method of induction of anæsthesia are matters of individual choice, but the maintenance should always be by the intra-tracheal administration of ether, or of chloroform if diathermy is likely to be used. The necessity for the intra-tracheal administration lies in the fact that the presence of the œsophagoscope may cause pressure on the trachea and lead to respiratory obstruction, while in some cases of a dilated œsophagus with obstruction the introduction of the œsophagoscope may lead to a sudden flooding of the hypo-pharynx with accumulated fluid from the œsophagus and the consequent danger of its inspiration unless the air-passages are guarded by the positive-pressure anæsthesia.

The use of basal anæsthetics such as avertin or evipan for œsophagoscopy has proved disappointing. They do not provide sufficient depth of anæsthesia to give muscular relaxation or to abolish the cough and retching reflexes, while, on the other hand, they cause a degree of unconsciousness which prevents the patient from co-operating with the operator. Their usefulness is therefore limited to their association with general anæsthesia. The same remarks apply in children to the use of nembutal by mouth or paraldehyde per rectum.

Technique of Œsophagoscopy.

Before commencing an œsophagoscopy, it is imperative that the operator should himself check the instruments and specially examine the lighting apparatus. A spare light-carrier should be prepared for each œsophagoscope, and duplicate electric leads fitted into the batteries. The suction apparatus must be tested, and the control of this delegated to a specific assistant. A second assistant is advisable in order to hand to the operator the requisite instruments.

The lay-out of the theatre should be a matter of routine. Preferably, the anæsthetist and his apparatus are placed to the left of the patient's head and of the operator, the latter sitting or standing at the head of the table. On the operator's right hand stands the instrument assistant with the table of instruments at his side and slightly behind the operator. The suction apparatus is immediately behind the operator, and when suction is required the aspirating tube is handed over the operator's right shoulder. Instruments are handed to the operator in a position ready for introduction.

A special endoscopic table or head-rest is not so essential for œsophagoscopy as it is for bronchoscopy. Any operating table with an easily adjustable head-end can be used. The theatre should be darkened and the operator should wear protective spectacles or a face-shield. At every endoscopic examination the instruments necessary for a tracheotomy must be ready for instant use.

The patient is placed lying on his back, with the head extended on the neck, i.e. at the occipito-atlantal joint (see fig. 2616). This extension must be maintained throughout the examination and is easy when the patient has relaxed under general anæsthesia. When the examination is being carried out under local anæsthesia, an occasional word of explanation and encouragement to the patient suffices. The raising or lowering of the head of the table will provide the flexion or extension of the neck that is required according to the position of the œsophagoscope.

The proximal end of the œsophagoscope is held in the right hand in pen fashion, while the index finger and thumb of the left hand encircle the tube to steady it. The other fingers of the left hand are hooked over the upper teeth and retract the upper lip to prevent it from being pinched between tube and teeth. The handle of the œsophagoscope is kept pointing upwards, for in this position the operator knows that the bevelled end of the tube is downwards. The tube enters the right angle of the mouth and the point is guided over the side of the tongue until the epiglottis is in view. The bevelled end is now sliding along the post-pharyngeal wall, and keeping to the right it enters the pyriform fossa. Passing on another 2 to 3 centimetres, the lumen disappears, the upper sphincter of the œsophagus—the crico-pharyngeus—having been reached. The point of the tube is now directed towards the mid-line and at the same time is firmly lifted by pressure of the left thumb. With the next inspiration, or if the conscious patient be asked to swallow, the sphincter opens and the lumen of the cervical œsophagus is seen ahead. The tube slips through easily and passes onwards readily. During this initial stage of introduction the head of the table must be raised so that the cervical œsophagus is in the same axial direction as the upper half of the thoracic œsophagus. With the further passage of the tube, the thoracic œsophagus is reached and the movements of expansion and contraction with respiration will be noted. The walls of the closed œsophagus are thrown into longitudinal folds, leaving an irregular star-shaped lumen which will probably fill with fluid œsophageal contents. The aspiration

tube may be passed down to remove these, as it is essential at all times to maintain a clear field of vision before passing the tube further down the œsophagus. It will now be noticed that the lumen of the œsophagus tends to disappear anteriorly, and to combat this change in direction the head of the table must be lowered coincidently with the further passage of the tube. At this point the pulsations of the aorta may be felt, and seen if the left anterior wall be inspected. The remainder of the thoracic œsophagus is easily traversed until the level of the diaphragm is reached. By this time the head will be lowered below the horizontal, and the lumen of the œsophagus will again disappear, but this time to the left. Moving the patient's head laterally to the right and searching the anterior wall of the lumen, the lower sphincter will be in view. This constriction will appear as a vertical slit, and moderately firm pressure is required to pass the œsophagoscope through it. Another 2–3 cms. and the cardia will be reached, appearing not as a constriction but showing by the rolling into the tube mouth of dark red folds of gastric mucosa and a gush of fluid from the stomach. Further passage of the tube constitutes a gastroscopy.

During the whole of the passing of the œsophagoscope the operator's eye must be at the tube's mouth, for it is imperative that the procedure should be carried out entirely under vision. The chief points to note are the size and shape of the lumen, the presence or absence of normal movements, the colour and surface of the mucous membrane—especially any tendency to bleeding—and, lastly, any abnormal contents.

The Œsophagus considered Endoscopically.

Congenital Malformations. These are all rare, and a large proportion are impossible to treat. From a diagnostic point of view it is of interest that it is possible to pass a 4 or 5 mm. tube in the new-born child, and in the case of an imperforate œsophagus such a procedure will provide conclusive evidence.

1. *Congenital Strictures.* These may not be suspected until the child's diet becomes more solid, and in some cases are not discovered until an endoscopic examination is made in the adult on account of dysphagia. The stricture is usually in the lower third of the œsophagus. On œsophagoscopy a narrowing of the lumen is found without scarring of the margins. In the case of adults with long-standing dysphagia there will be seen dilatation of the œsophagus above and some evidence of chronic œsophagitis in the region of the stricture resulting from the irritation of delayed food. Occasionally an unusually large piece of food is found impacted in the narrowed lumen. The treatment is by gradual dilatation by bougies similar to that for acquired strictures (see page 4826). This should always be done under vision and in gradual stages ; otherwise it may need to be repeated throughout life at varying intervals, owing to the formation of scar tissue at the site of the stricture and the transformation of a congenital into an acquired stricture.

2. *Webs and Membranous Obstructions.* Partial or complete closure of the œsophageal lumen by a membranous diaphragm may be diagnosed endoscopically. The former is best seen when the œsophagus is examined with a large-size tube so that the walls are put on the stretch. As Abel points out, infants with complete œsophageal obstruction should be examined endoscopically on the chance that the obstruction is due to a thin membrane, since this is a curable condition. The mere passage of the œsophagoscope is usually sufficient to rupture the membrane ; if not, careful bougienage must also be employed.

3. *Short Œsophagus.* The endoscopic appearances in this interesting condition have been fully described by Brown Kelly (*Journal of Laryngology and Otology*, 1931, XLVI, 797). He finds that the stenosis shown radiologically is, in fact, the diaphragmatic and abdominal parts of the normal œsophagus, while the section of the alimentary canal between the stenosis and the hiatus œsophagus of the diaphragm is not a dilated lower part of the œsophagus but the upper part of the stomach in the thorax. When examined with the œsophagoscope a dilated œsophagus is found down to the level of the stenosis, where the lumen gradually narrows without change in the appearance of the lining membrane. The endoscope will then be found to pass with little difficulty along the stenosis, which may vary in length from 0 5–2 cms, into a space lined with gastric mucosa. The identity of this space with the stomach or a portion of the stomach may be confirmed by observing the change in reaction of the secretion above and then below the stenosis, or by removing a portion of the lining membrane below the stenosis for microscopical examination. If dysphagia arises in this condition from cicatricial

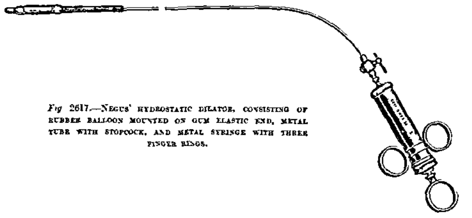


Fig 2617.—Negus' hydrostatic dilator, consisting of rubber balloon mounted on gum elastic end, metal tube with stopcock, and metal syringe with three finger rings.

stenosis, gradual dilatation is indicated. This may be carried out by graduated bougies or by a rubber bag distended with water as advocated by Negus (fig. 2617).

Foreign Bodies in the Œsophagus.

For a complete account of the various problems concerned with the endoscopic removal of foreign bodies in the œsophagus the reader is referred to Chevalier Jackson's *Diseases of Air and Food Passages of Foreign Body Origin*, 1936.

It must be emphasised that the treatment of a *suspected* foreign body in the œsophagus should be by an endoscopic examination with removal of the foreign body at the same time. Endoscopy for the purpose of a preliminary look is not justified, so that all instruments likely to be needed for the removal must be prepared.

The usual preparation for œsophagoscopy should be carried out as far as is possible, bearing in mind that the presence of a foreign body is in the nature of a surgical emergency. The preliminary X-ray examination may help to locate the level of impaction and give some idea of the size of the foreign body, but in the face of history and symptoms a negative X-ray report must be ignored. If it is possible to obtain a duplicate of the swallowed object the particular problem of its removal may be studied and practised in the interior of a rubber tube of approximately the same size as the patient's œsophagus.

General anæsthesia administered by the intra-tracheal method is more suitable than local anæsthesia for the removal of foreign bodies. There is frequently spasm associated with the impaction of the foreign body and there may be, in addition, considerable swelling of the mucosa of the œsophagus so that the relaxation of the muscular walls will permit the introduction of the œsophagoscope and the removal of the foreign body with less likelihood of trauma. The possible dangers of respiratory obstruction occurring during anæsthesia from the presence of the foreign body, especially if large, are obviated by the intra-tracheal method of administration.

Great care must be exercised during the introduction of the œsophagoscope, since there may be considerable alteration in the usual landmarks due to œdema of the mucous membrane not only at the level of the impacted foreign body but well above it. It is easy for the advancing lip of the tube to push a fold of mucous membrane in front of it, causing the foreign body to be overlooked or even pressed upon with the consequent danger of further damage to the walls of the œsophagus. The foreign body may be obscured also by secretion and food debris or by bleeding induced by the manipulation. Constant aspiration must be employed to keep the field of vision as clear as possible. As soon as the foreign body is seen, the tube must be manipulated to determine its exact position relative to the lumen of the œsophagus and especially to decide whether any part of the foreign body is embedded in the œsophageal wall. The first step in removal must be the proper manipulation of the foreign body to disimpact it; secondly, to see that it is held in forceps in such a position that any sharp points it may possess will trail behind during removal; thirdly, gently to draw the foreign body into the tube mouth if this is possible, but more often to hold it firmly against the tube mouth, when the œsophagoscope, forceps and foreign body are withdrawn as one. The particular problems are concerned with the second stage, i.e. the manipulation of the foreign body into the proper position for removal. Such a problem is well illustrated in the case of an open safety-pin, which is usually swallowed with the point uppermost. Jackson describes sixteen methods of dealing with this, of which the principal are:

(1) By sheathing both ends of the pin into the mouth of the œsophagoscope (best for pins not widely spread).
(2) By version of the pin in the œsophagus. The spring of the pin is grasped in rotation forceps (see fig. 2608, D) and is pulled towards the mouth of the œsophagoscope which is directed strongly away from the pointed end, and so allows the point to trail through 180 degrees.
(3) By version in the stomach. The spring is held in rotation forceps and the pin is pushed into the stomach where it easily rotates when withdrawn against the mouth of the œsophagoscope.
(4) By sheathing the point. The point is seized by Tucker forceps (see fig 2608, E) and drawn into the œsophagoscope in such a way that only the smooth keeper branch remains between the tube and the œsophagus.

Other points to bear in mind with particular foreign bodies are:

(1) A flat foreign body must be turned so as to bring its greatest plane coronally, since this is the way it went down behind the cricoid.
(2) Tooth-plates are frequently fitted with wire loops which constitute dangerous sharp points when manipulating them.
(3) Food particles are uncommon foreign bodies in a normal œsophagus.

Following the removal of the foreign body, the patient should be kept in bed. In the case of the removal of smooth objects where it is certain that no injury has been caused to the œsophageal walls, ordinary soft food may be given at once, but to all other patients nothing should be given by mouth except boiled water for the first 24 hours. If the general condition of the patient demands it, rectal feeding must be employed. Anxiety lest a serious complication may arise will not

Fig. 2618.—X-ray photograph of a traction diverticulum of the œsophagus.
(Photograph by H. M. Worth.)

pass until the patient has a normal temperature and pulse-rate, a clean tongue, and no dysphagia, and it is most important to keep the patient under close observation during this period.

Diverticula of the Œsophagus.

Apart from the pulsion diverticula occurring at the pharyngo-œsophageal junction, diverticula of the œsophagus are rare and are usually observed accidentally during an œsophagoscopy for some other reason. They consist of two types, pulsion and traction diverticula. The former are found in the region immediately above the diaphragm and are probably congenital. The traction diverticula are due to adhesion between the œsophagus and glands in the region of the bifurcation

of the trachea. Hence they are found at this level and mainly on the anterior wall (fig. 2618).

The so-called "œsophageal pouch" or pharyngeal diverticulum may be *observed endoscopically* (fig. 2619). Its *opening occurs at the upper constriction* of the œsophagus and the pouch herniates posterior to the œsophagus

A. B.

Fig 2619.—X RAY PHOTOGRAPHS OF A PHARYNGO ŒSOPHAGEAL POUCH.
[*Note.* The pouch is posterior to the œsophagus.]
(*Photographs by H. M. Worth.*)

through a gap between the circular and oblique fibres of the inferior constrictor of the pharynx. *When the œsophagoscope is introduced, its tip tends to slip into the* open mouth of this hernia rather than through the closed upper sphincter of the œsophagus, which may be found above and anterior to the opening of the pouch (fig. 2620). It is difficult to bring both openings into view at once since the tip *of the tube is at this level balanced behind the cricoid. The interior of the pouch* may be viewed and its extent estimated. Its walls are often ulcerated and coated with food debris and, being thin, care must be taken not to perforate them.

Fig 2620.—ENDOSCOPIC VIEW OF PHARYNGO ŒSOPHAGEAL POUCH. NOTE THE OPEN LUMEN OF THE POUCH. (*Abel.*)

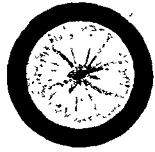


Fig 2621.—ENDOSCOPIC VIEW OF FIBROUS STRICTURE OF THE ŒSOPHAGUS. (*Abel.*)

Endoscopy is of value in treatment only as a guide to the surgeon performing an external operation (see Vol. II, page 1905).

Inflammatory Diseases of the Œsophagus.

Endoscopy is not advisable in any case of acute œsophagitis. If signs of obstruction develop during the healing stages it is wiser to defer œsophagoscopic examination until the inflammatory condition is quiescent, which may be assumed when there is no pain on swallowing. The subsequent treatment is that of any stricture present.

In cases of acute phlegmonous œsophagitis where it is suspected that a localised abscess has formed, it is justifiable to perform an œsophagoscopy and to attempt the incision of the abscess into the lumen of the œsophagus. The previous removal of a perforating foreign body may lead one to expect the possible development of such a condition. The patient is gravely ill and complains of complete œsophageal obstruction with agonising localised pain on any attempt at swallowing. The writer believes that the best chance of recovery from such a condition is secured by keeping the œsophagus at rest by rectal or gastrostomy feeding and in delaying any endoscopic procedures in the hope that the suppurative area will become localised. The abscess will then usually burst into the lumen of the œsophagus, but, should it not do so, endoscopy may be performed and an incision made into it.

Œsophagoscopy is occasionally required in the diagnosis and treatment of patients with chronic œsophagitis, but this condition is usually secondary to some other œsophageal lesion or is found in alcohol addicts and smokers. In addition to removing the cause, any areas of ulceration or erosion may be treated weekly with silver nitrate 10 per cent solution applied on a bronchoscope swab. The same treatment is applicable to the peptic ulcer of the œsophagus, though this is rarely required.

Cicatricial Stenosis of the Œsophagus

Strictures resulting from the swallowing of a corrosive fluid are usually found at the anatomical levels at which narrowing of the œsophagus occurs. They are frequently multiple. The endoscopic appearances vary according to the stage of the lesion (see fig. 2621). In a recent burn there may be considerable ulcerative and bleeding areas. Later, scarring takes place and with the resultant obstruction dilatation will occur above. There may be dilatation between two strictures, with the stagnation of food and consequent œsophagitis. The colour of the scarred area is usually paler than that of normal mucosa. Usually the scar is eccentric and involves only a part of the circumference of the wall. Occasionally it is annular. The normal movements of the œsophagus may still be present if the amount of scar tissue is small. If the lumen is not too much reduced it may be possible to see another stricture beyond the first, with a dilatation of the œsophagus between.

The endoscopic treatment consists of gradual dilatation of the stenosis with bougies passed under direct vision. Any blind bouginage must be condemned as dangerous. The œsophagoscope is passed down to the level of the stricture, food debris and secretion removed, and the lumen of the stricture centred in the line of vision. An œsophageal bougie (see fig. 2607) is then passed gently through the stricture, using a size which can just be passed. This is left *in situ* for a minute and then a size larger is substituted. Several successive sizes are used and then the whole procedure is repeated in a week's time. When a lumen of 7–10 mm. has been reached, the treatment may be carried out at longer intervals and then subsequently

as may be necessary. The more gradual the dilatation, the better the result. No *force must be used at any stage for fear of splitting the œsophagus.*

In some cases the lumen of the œsophagus is so small and so tortuous that the passage of a bougie is impossible. Retrograde dilatation via a gastrostomy is then needed. The patient is given a length of silk thread to swallow, which eventually finds its way through the stricture into the stomach and even through the pylorus. The tight length of thread in the stomach may be fished for in the gastrostomy wound and attached to a Tucker bougie of small size. A fresh string is attached to the other end of the bougie, which is drawn through the stomach up into the œsophagus and through the stricture. The newly attached string serves for the attachment of a second bougie. Sizes are increased only at *long intervals; never until a preceding size comes up loosely.*

Neoplasms of the Œsophagus.

(1) *Innocent.* Innocent tumours of the œsophagus are exceedingly rare and are usually discovered accidentally during the course of an œsophagoscopy. Guisez noted only 3 benign tumours among 3000 tumours of the œsophagus. They may be pedunculated or sessile. The former often arise in the pharynx with the main mass hanging into the œsophagus. They may be removed by simple avulsion, by diathermy, or by snaring. Sessile tumours are rarely diagnosed during life.

(2) *Malignant.* Endoscopy is required to confirm the diagnosis of malignant disease of the œsophagus and is the principal means at our disposal at present for its treatment, both palliative and active.

Diagnosis. While the endoscopic appearances of a carcinoma of the œsophagus leave little doubt as to its nature, it is customary before commencing treatment to confirm the diagnosis by biopsy. Special sharp cupped-end forceps are made for this purpose and in removing a portion of the tumour it is wise to try and obtain a specimen from the main mass of the growth and also from its growing edge.

On endoscopy, the lumen of the œsophagus will be seen to be filled with thick white frothy mucus and food debris. This must be removed by the suction apparatus and great care taken that the point of the aspirator does not touch the walls of the œsophagus and induce bleeding, which is extremely prone to happen. If there has been long-standing obstruction, a fair degree of dilatation of the lumen will be seen above the level of the growth especially if this is at the lower end. As the stricture is approached, the walls of the œsophagus appear thickened by infiltration and do not show the normal respiratory movements. Further careful cleaning by suction or mopping will reveal the surface of the growth. The appearances of this vary according to the type of tumour:

(1) Polypoid—projecting type.

(2) Ulcerating type.

(3) Infiltration beneath mucosa—scirrhus type. (See figs. 2622, 2623 and 2624.)

(1) The lumen of the gullet is obstructed by epitheliomatous exuberant granulations, covered with purulent secretion, more or less pedunculated, easily detached, and bleeding at the slightest contact. The projecting tumour may occupy more than half the circumference of the lumen, reducing the canal to a slit. The attachment of the granulation is on a broad base which is raised above the surrounding mucosa so as to form an elevation.

(2) A more or less large ulcer is situated on one aspect of the mucous membrane

which is indurated and raised above the surrounding surface. The base of the ulcer is purulent. The edges are projecting, crateriform, and bleed readily.

(3) The wall in a certain area is raised and infiltrated beneath the surface. It presents a fixed appearance, contrasting with the mobility of the opposite side. The surface of the area is smooth or granular and bleeds at the slightest touch. The infiltration may often extend for some distance under the mucosa and approximate to the opposite wall so as to cause stenosis.

Finally, all types may be combined, especially when the disease is advanced.

The appearances common to all types are the immobility and thickening of the wall upon which the disease is situated, and the abnormal tendency to bleeding.

By the time that a carcinoma of the œsophagus causes symptoms of dysphagia, it is already in an advanced stage and treatment is unlikely to be more than temporarily successful. It would seem that the opportunity for improving results

Fig 2622.—Endoscopic view of carcinoma of the œsophagus. Polypoid type. (*Abel*)

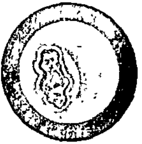


Fig 2623.—Endoscopic view of carcinoma of the œsophagus. Ulcerating type. (*Abel*)

Fig. 2624.—Endoscopic view of carcinoma of the œsophagus. Scirrhus type with commencing proliferation. (*Abel*)

in treatment must depend on earlier diagnosis. To this end it is necessary to emphasise again and again the need for œsophagoscopic examination in all patients complaining of minor disturbances in swallowing.

Treatment. Endoscopic treatment consists of:

(1) Dilatation by bougies.

(2) Intubation.

(3) Removal of the growth; morcellement.

(4) Diathermy.

(5) Insertion of radium in lumen; implantation of radon seeds.

(1) *Simple dilatation* of the stricture of the œsophagus with graduated sounds is the customary palliative method of treatment in the Mayo Clinic, as described by Vinson and Moersch. The dilatation can be carried out more quickly than is the case with simple strictures. In 502 dilatations for carcinoma carried out at the Mayo Clinic in 6 years, there were only 3 fatalities due to splitting of the œsophagus. The majority of patients can swallow fairly normally for a period of 6 to 8 weeks, after which the process may be repeated.

(2) *Intubation* is carried out by the introduction of some kind of tubular funnel into the œsophagus, this being passed into the narrowed part of the lumen and maintaining a passage for food by tunnelling the growth. The original tube was introduced by Charter Symonds and was composed of gum elastic. Souttar has advocated the use of a tube made of a coil of German-silver wire. It has a cone-shaped upper end which rests on top of the stricture, and to prevent upward move-

ment the tube is made oval in section and a spiral twist is given to the oval. The insertion is done via an œsophagoscope under vision. A large-diameter œsophagoscope is required in order to permit the introduction through it of the tube.

The method of insertion is as follows: " After dilating the stricture as far as is considered safe, a tube of suitable size (fig. 2625, C) is selected and is threaded on to an introducer (fig. 2625, D). This slides over the guide wire (fig. 2625, top)

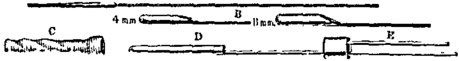


Fig 2625.—Set of instruments used by H. S. Souttar for dilatation of œsophageal stricture and introduction of intubation tubes.

which is still in place and serves to steer the lower end of the tube through the stricture. The introducer and the guide bougie are now withdrawn through the ring (fig. 2625, E) which is then itself withdrawn and the tube is left in place, its expanded upper end resting on the face of the stricture." (*B.J.S.*, July 1927, 89.) (Fig. 2626.)

The method is applicable to growths in all situations except the cervical œsophagus. In the large majority of cases the immediate result is very satisfactory.

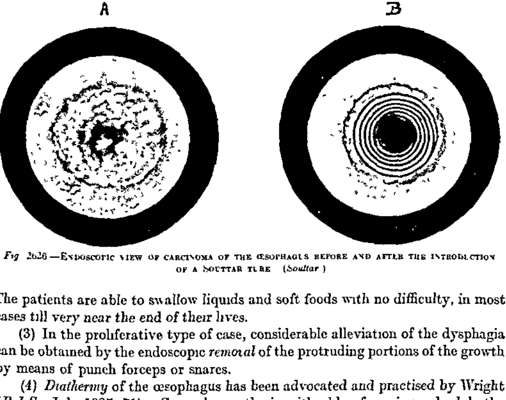


Fig 2626.—Endoscopic view of carcinoma of the œsophagus before and after the introduction of a Souttar tube (*Souttar*.)

The patients are able to swallow liquids and soft foods with no difficulty, in most cases till very near the end of their lives.

(3) In the proliferative type of case, considerable alleviation of the dysphagia can be obtained by the endoscopic *removal* of the protruding portions of the growth by means of punch forceps or snares.

(4) *Diathermy* of the œsophagus has been advocated and practised by Wright (*B J S.*, July 1927, 71). General anæsthesia with chloroform is used while the actual operation takes place. A large-sized œsophagoscope is passed, and the region of the growth rendered as dry as possible by careful suction. The special electrode used consists of a long insulated shaft and handle to the end of which various terminals can be screwed. The terminals consist of (*a*) a disc 7 mm. in diameter;

(*b*) a small spike; and (*c*) a gum elastic bougie end with, at its *base*, a conical metal ring which forms the actual terminal. If the growth involves one portion of the circumference only, the disc or spike electrode can be applied under direct vision. Often, however, where the growth is forming an annular narrowing, it is difficult to judge when the lower end of the growth has been reached if the diathermic destruction is carried out from above downwards, and a severe risk is taken of damaging normal œsophageal wall In such a case the bougie electrode is used and is passed under vision through the stricture, as large a size of bougie end being used as is possible. It is then slowly withdrawn until the conical base of the bougie end meets with the resistance of the lower end of the growth. At this point the current is switched on and continuous traction made on the instrument until it cuts its way out and comes into view at the upper end. Wright believes that at least a fortnight should be allowed to pass before deciding as to the result of any one application and that any further application should not take place sooner than a month. Diathermy can be employed on any patient provided the general condition will permit an œsophagoscopy. The whole procedure takes a very short time and the amount of shock produced is extremely slight. If the general condition is bad, a gastrostomy may be performed first. No cures by diathermy have been recorded, but it enables a food passage to be established without undue risk or suffering to the patient as a result of the operation.

(5) *Radium and Radon Seeds. Radium* may be applied to the lumen of the œsophagus in a container or by inserting needles into the wall. The latter is dangerous as it is difficult to anchor the needles or to extract them when sufficient radiation has taken place Thus for actual insertion into the growth radon seeds are used.

Various methods of applying radium in a container have been adopted. Guisez advocates placing the radium in a special long œsophageal catheter which can be fixed externally to the patient's head so that its position in the œsophagus is kept constant. The required dose of radium is suspended in the lumen of the catheter and sewn in position.

It is important:

(*a*) To measure the exact length of the growth and its distance from the incisor teeth;
(*b*) That the patient should not be too cachectic;
(*c*) That the remnant of œsophageal lumen should be recognisable and still permeable;
(*d*) That there should be no demonstrable extensions of the growth.

The length of the growth is decided by a previous œsophagoscopy and by the passing of an olive-headed bougie through the stricture, and then noting the point at which the olive is held up when withdrawing it. Also preliminary skiagrams, taken with the patient first upright and then in the Trendelenburg position, will give further evidence as to the length of the stricture An œsophageal catheter of a size that comfortably fits the lumen of the growth is used and the appropriate dose of radium is fixed into it. The catheter is then passed down the œsophagus to such a distance that the portion containing the radium is accurately placed in the stricture. The application of radium is made every 2 days for 10-12 hours, and 5 or 6 sittings constitute a complete treatment.

Other workers have applied the radium to the outside of an intubation tube, such as Souttar's, fixing it to strapping which is bound sticky side out, and covering the whole with a special band of thin dental rubber. The radium is applied to a length of the tube corresponding to the length of the stricture and in some cases specially long tubes are needed. The disadvantage of this method is that there is no means of preventing the tube from slipping upwards (its possible movement downwards can be prevented by a thread attached and brought out of the mouth).

Musgrave Woodman in advocating the use of radon inserted into the growth makes the following points against the use of radium in containers in the lumen of the growth (*Journal of Laryngology and Otology*, 1929, XLIV, 584):

(*a*) The difficulty of fixation.
(*b*) The central dose is in contact with the oldest part of the growth and is furthest from the active-growing edge.
(*c*) Radium in contact with sepsis increases septicity.
(*d*) The presence of a mechanical appliance in the lumen for any length of time tends to be followed by ulceration and stricture formation.

He describes the insertion of radon seeds into the substance of the growth and points out that their activity is of limited duration and that they may therefore be left in the tissues.

Radon seeds are inserted by means of a special trocar and cannula introducer (see fig. 2609) which has its proximal end marked in centimetres. Under direct vision the instrument is passed into the upper edge of the growth and pushed downwards into its substance in the wall of the œsophagus to a distance just short of the known length of the stricture. The trocar is then withdrawn, a seed put into the cannula, and the trocar re-inserted to push the seed out into the tissues. The cannula is then withdrawn one centimetre and the procedure repeated. It is possible to place several seeds in line one above the other in this way. The insertion is then repeated in another part of the circumference of the growth and another column of seeds introduced. Negus advocates four introductions of seeds round the circumference and as many as three seeds in each. Jobson and Steele have combined this method with a gastrostomy and the insertion of further seeds from below by retrograde œsophagoscopy through the gastrostomy opening, but it is doubtful if this is necessary. An X-ray examination of the patient after operation will demonstrate the seeds *in situ* (fig. 2628). Sometimes it is found that some of the seeds have been re-inserted into the lumen and so lost. Others are eventually found to have passed into the mediastinum, though this causes no harm.

LARYNGOSCOPY, TRACHEOSCOPY, AND BRONCHOSCOPY.

Endoscopic examinations of the air-passages are conveniently described together, since a direct laryngoscopy is a necessary part of the introduction of the bronchoscope into the trachea and bronchi. The functioning of the laryngeal muscles can best be studied by the use of the laryngeal mirror, as the presence of the direct laryngoscope may cause reflex spasmodic movements and some distortion of position.

Recent developments in thoracic surgery have emphasised the importance of bronchoscopy, for it is an essential preliminary examination to all operations on the lungs.

Fig. 2027.—Skiagram of a carcinoma of the middle third of the œsophagus, showing dilatation above a stricture.
(*Photograph by H. M. Worth.*)

Fig. 2028.—Skiagram of a carcinoma of the lower third of the œsophagus with radon seeds in situ.
[*Note.* The seeds do not radiate the upper end of the growth. A second insertion of seeds was made as a result of this radiological information.]
(*Photograph by Lindsay Locke. Author's case.*)

Indications for Endoscopy of the Air-Passages.

(1) Suspected foreign body.
(2) For information as to the site and extent of any pulmonary and many mediastinal lesions.
(3) For the collection of uncontaminated secretion for culture.
(4) For the purposes of biopsy.
(5) For the introduction of lipiodol into a particular part of the tracheo-bronchial tree.
(6) For the treatment of many laryngeal and pulmonary diseases.

Contra-Indications.

There are no contra-indications to the removal of a foreign body.

In all other cases the contra-indications are relative, and the condition of the patient should be a matter for discussion between physician, thoracic surgeon and radiologist. Generally speaking, it is unwise to do a bronchoscopy on patients with advanced cardiac disease, aortic aneurysm, purulent pneumonia, multiple abscess formation, and active tuberculosis, especially with laryngeal involvement or pneumothorax.

Preparation of the Patient.

It is assumed that all patients, except those with a suspected foreign body, have already received a general medical examination before the question of endoscopy arises. In all cases a full X-ray examination of the chest must be carried out and, when a foreign body is suspected, this must be done immediately before the endoscopy. A preliminary examination of the throat and larynx with

the laryngeal mirror should be made in order to exclude any local disease which might contra-indicate the endoscopy. A brief description and explanation of the proposed examination should be given to the patient beforehand, especially to dispel any fears he may have with regard to suffocating while the tube is in the larynx. Preliminary instruction as to breathing and the position required of him will enable the operation to be carried out more easily and more expeditiously. This is particularly important when the patient has had pre-operative medication with morphia and hyoscine and therefore may not so readily understand instructions given during the examination.

Anæsthesia. Endoscopic examination of the air-passages is best carried out under local anæsthesia. The giving of a general anæsthetic may be permissible, but it adds to the difficulties of the operator. An intra-tracheal anæsthetic catheter lies comfortably in the posterior part of the larynx between the arytenoids, and its presence does not interfere with the passage of endoscopic tubes. On the other hand, the anæsthetic vapour is constantly a source of irritation to the operator's eyes, it causes congestion of the mucous membrane of the bronchi and trachea and thus increases the secretions, and, finally, there may be a haziness of definition of objects seen beyond the tube mouth. When local anæsthesia is used, a preliminary injection of morphia, atropine and hyoscine may be given, as detailed in the

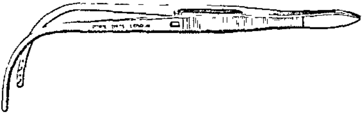


Fig. 2629.—Laryngeal forceps for use in anæsthetising the pyriform fossa.

section on œsophagoscopy. The anæsthesia is obtained with a 10 per cent cocaine solution and is carried out as follows: Two or three sprayings of the mouth and pharynx are followed a few minutes later by the application of a swab which is held in a pair of laryngeal forceps (fig. 2629), dipped in the cocaine solution, and then introduced into each pyriform fossa for about two minutes. If the swab is passed slowly over the side of the tongue with the patient breathing quietly, it will slip into the corresponding pyriform fossa. By this means anæsthesia of the larynx is obtained by the blocking of the superior laryngeal nerve. With a laryngeal mirror the larynx is then inspected and, with a special syringe and cannula, $\frac{1}{2}$ to 1 cc. of cocaine solution is dropped through the glottis into the trachea. This will probably induce a cough and so help to scatter the cocaine solution over the tracheal walls. Should coughing be troublesome during the subsequent manipulations in the bronchi, a further local application of cocaine will be made as required. The most sensitive situations would appear to be the bifurcation of the trachea and around any intermediate bronchial spur.

Endoscopic Anatomy of the Trachea and Bronchi.

Figure 2630 shows the trachea and its division into bronchi and these again into sub-divisions for the various lobes of the lungs. The endoscopic appearances at certain levels are indicated, but it must be realised that the diagram requires turning upside down to obtain the view as seen during bronchoscopy. The trachea appears as a tube slightly flattened on its posterior wall, its mucous membrane is moist and glistening, whitish in circular ridges corresponding to the cartilaginous

rings and reddish in the intervening grooves. The trachea is about 12 cms. long, and at the level of the second costal cartilage bifurcates into left and right main bronchi. The septum between the two main bronchi, known as the carina, is situated to the left of the mid-tracheal line. It appears as a sharp spur-like ridge running vertically as viewed in the recumbent patient and widening a little at each end. It is important to note its appearances, as they may be altered by any displacement of the main bronchi or by changes in the inter-bronchial space. The right main bronchus is more nearly in a straight line with the trachea than is the left bronchus and, in fact, may appear as a direct continuation. It almost immediately shows on its right wall a smaller edition of the carina, the spur between the main bronchus and that to the right upper lobe. The orifice itself can be seen only partially when it is brought into view by extreme lateral displacement of the patient's head to the left, owing to the sharp angle which the upper lobe bronchus makes with the main bronchus. About 3 cms. further down the right main bronchus another branch is seen, that to the middle lobe. This arises from the anterior wall, and thus the spur appears as a horizontal edge, being seen more easily if the patient's head is lowered. Beyond this point the main bronchus becomes the inferior lobe division and can be seen in the distance sub-dividing repeatedly into its terminal branches. The left main bronchus is more difficult to examine, as it makes an angle with the trachea of about 105 degrees; in other words, there is a change of direction of about 75 degrees. It can only be entered by displacing the head to the right. The upper lobe bronchus is not found so near to the carina on this side, the left main bronchus being about 5 cms. long. Rather more of the lumen of this opening is seen than on the right side, since the upper lobe bronchus does not make such an acute angle with the main one. Beyond this point is seen the left inferior lobe bronchus with its sub-divisions in the distance.

The movements of the bronchi seen during a bronchoscopy are mainly respiratory, though the transmitted pulsations of the heart may be felt. The respiratory movements cause the bronchi to dilate and elongate with inspiration, so that when viewed through the bronchoscope a given point will recede and approach while the lumen dilates and contracts. Advantage is taken of these movements in bronchoscopy, for the inspiratory enlargement of the lumen permits a deeper inspection, and in the case of foreign bodies provides the necessary space for the introduction of the end of the forceps over the foreign body.

Technique of Endoscopy of the Air-Passages.

The arrangements of the various tables in the theatre and the preliminary examination of instruments have been described in the section on the technique of œsophagoscopy.

It is essential to use an operating table with a special head-rest which can maintain the patient's head in the correct position of extension and also allow for movements to either side and of raising and lowering (see figs. 2612 and 2613).

The patient lies on his back with the head fitting snugly into the head-rest. The importance of the maintenance of extension of the head is explained to the patient and is best described as a position in which the chin is pointed towards the ceiling.

Laryngoscopy.

Anæsthesia having been completed, the first stage of the examination is the

introduction of the laryngoscope. The laryngoscope is held in the left hand in such a manner that the greatest amount of traction is made on the horizontal bar rather than on the vertical. The right hand is kept free for the manipulation of forceps and the introduction of the bronchoscope. The spatular end of the laryngoscope is introduced in the right side of the patient's mouth along the right side of the

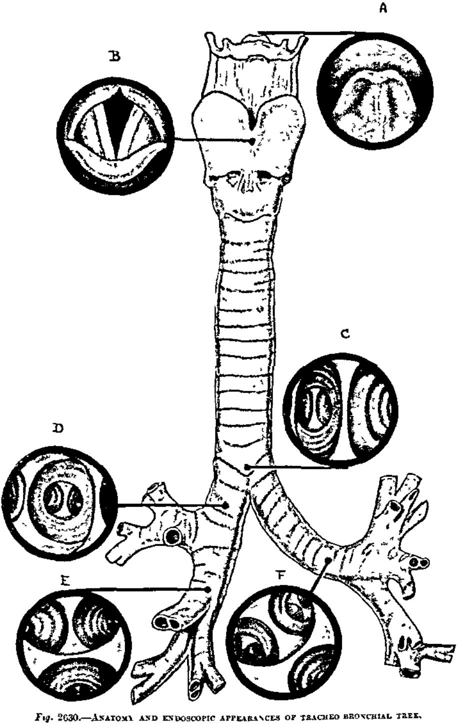


Fig. 2630.—Anatomy and endoscopic appearances of tracheo bronchial tree. (*Modified after Haslinger.*)

[*Note* To obtain the correct endoscopic views the picture must be looked at upside down.]

anterior two-thirds of the tongue. It is better to avoid the mid-line of the mouth since this necessitates passing over the dorsum of the tongue and considerable force may then be required in the next stage. When the posterior part of the tongue is reached the tip of the laryngoscope is directed towards the mid-line, and the dorsum of the tongue is elevated by a lifting motion imparted to the laryngoscope. The epiglottis will then be seen to project into the field (see fig. 2630, A). In the next stage the spatular end is tipped towards the post-pharyngeal wall, passed behind the epiglottis and gently pushed onwards for about 1 cm. The tip of the spatula is now raised by a lifting action of the whole laryngoscope and not by a lever action against the upper teeth. The raising of the tip, and by it of the epiglottis, brings the glottis into view If the laryngoscope has been pushed onwards too far behind the epiglottis the tip may have passed behind the arytenoids also and the subsequent lifting will not expose the glottis but probably the region behind the cricoid. The larynx should now be in view and may or may not be in a state of spasm according to the degree of anæsthesia. With the next inspiration the vocal cords will be seen. and beyond them it may be possible to see the lumen of the trachea During the whole of this stage of the examination the patient's head remains elevated. If the anterior part of the larynx is not visible, it may be brought into view by a further lifting of the laryngoscope and by raising the patient's head still higher

Abnormalities of the larynx may be noted. but, as mentioned above, accurate observation on the movement of the vocal cords is best carried out by indirect laryngoscopy. Innocent tumours of the vocal cords may be removed by cupped forceps, and great care must be taken to avoid injury to the underlying structure or permanent impairment of the voice may result. The forceps can be introduced into the larynx through the laryngoscope, or may be passed through the mouth alongside the speculum. In either case the actual manipulations must be carried out strictly under vision. Similarly, portions of a tumour may be removed for pathological examination. Direct laryngoscopy also is employed for the cauterisation of the larynx either with caustics applied on a wool-coated probe or with the galvano-cautery for tuberculosis of the larynx. Malignant disease of the larynx is not usually treated endoscopically.

It is unwise to maintain exposure of the larynx for more than a few minutes, as the prolonged presence of the laryngoscope is uncomfortable to the patient and the operator's left hand quickly tires. All intra-laryngeal procedures must therefore be carried out expeditiously, but at the same time with the utmost care.

Bronchoscopy.

The first stage of bronchoscopy consists in the exposure of the larynx. The bronchoscope is then held in the right hand and its point inserted into the laryngoscope. The operator's eye is now transferred to the bronchoscope and the latter is advanced under vision until the glottis is reached. The bronchoscope is then turned to one side so that the bevelled end is in the centre of the glottic space and is gently pushed between the vocal cords and so into the trachea. No force must be used and, in fact, is not needed if the introduction is properly made. When the bronchoscope has been advanced about one inch into the trachea, the laryngoscope is removed from the mouth by allowing its handle to rotate to the left, when the bottom slide may be withdrawn and the main part of the laryngoscope lifted away from the bronchoscope and handed to the assistant. During this pro-

cedure care must be taken to see that the bronchoscope is not pulled out of the trachea. With the bronchoscope now in the trachea, further advance may be made while the walls of the trachea are inspected. Gradual lowering of the head by the assistant will keep the direction of the tube the same as that of the part of the trachea about to be entered. The bronchoscope may be inserted without the preliminary exposure of the larynx, and this is sometimes an advantage in patients who have a full set of teeth and consequently less room for manipulations. *In this case the preliminary part of the passage of the bronchoscope is the same as* for the laryngoscope.

When the lower end of the trachea is reached, the carina must be identified and its position and shape examined. Any thickening or flattening of the spur will suggest that there is some abnormality at the root of the lungs, most commonly glandular enlargement.

By *turning the patient's head fully to the left the tube enters the right* main bronchus which is subjected to a general scrutiny as regards size, secretions, and character of mucous membrane. By *turning the patient's head extremely* to the left and pointing the tip of the bronchoscope to the right, the spur of the right upper lobe bronchus is visible though not its whole lumen. Returning to the main bronchus and lowering the patient's head, the upper wall of the bronchus is followed down until the spur of the middle lobe bronchus is visible. Then, raising the head again, the remainder of the main bronchus or, more properly, the lower lobe bronchus is examined together with its terminal sub-divisions. The tube is then withdrawn as far as the trachea, the carina again identified, the patient's head turned well to the right, and the left main bronchus entered. Keeping the head up and further to the right, the left upper lobe bronchus is searched for on the lateral wall. Beyond this the lower lobe bronchus is entered and examined for about 2 cms. The examination of the left bronchi is more difficult than of the right and is dependent on the ability of the patient to move the head sideways. Further help is obtained by keeping the tube in the right corner of the mouth.

During the whole of the examination of the bronchi the aspirator must be ready to hand to remove secretions before the tube is advanced. Care must be taken to prevent the tube mouth from pressing against the bronchial walls more than can be helped, and especially to guard against injury to the spurs between the bronchi. The less the walls are touched the less coughing will take place. The presence of excessive or abnormal secretion is noted and, if possible, the particular bronchial orifice from which pus is coming is searched for after aspiration. It may be necessary to ask the patient to give a slight cough to expel pus into the main bronchus for this purpose Any abnormal direction of the main bronchus will be observed and may make the introduction of the broncho-*scope unusually difficult. While the bronchoscope is in the main bronchi the* respiratory movements will be noted.

After a general survey of the bronchial tree, the particular part requiring examination is again found and examined more closely. If there is not too much secretion present, the telescope is inserted and a magnified view of the region obtained. The necessary further examination or treatment is then carried out as quickly as possible and the bronchoscope withdrawn. Except in unusual circumstances the bronchoscope should not be allowed to remain *in situ* for more than fifteen minutes.

ENDOSCOPIC APPEARANCES AND PROCEDURES IN DISEASE OF THE LARYNX, TRACHEA AND BRONCHI

Congenital Abnormalities.

Congenital abnormalities of the larynx, trachea or bronchi are very rare. Webs may be found in the larynx and removed with punch forceps or broken down by means of bougies. Œsophago-tracheal or œsophago-bronchial fistulæ and diverticula of the trachea may be diagnosed endoscopically, but no treatment is possible Congenital stenosis of the bronchus, usually by a thin web, has been described and is easily treated by dilatation with bougies passed endoscopically under vision.

Stenosis of the Trachea and Bronchi.

Stenosis may occur by reason of a localised thickening of the walls of the trachea or bronchi, or it may occur as a result of compression by outside structures.

Inflammatory thickening of the bronchial walls is especially associated with the presence of a foreign body It is also seen in conjunction with lung abscess and bronchiectasis, either as cause or effect or both. On the other hand, the inflammatory lesion may result in stenosis from subsequent scarring. Neoplastic changes in the walls of the bronchi, either innocent or malignant, will lead to an increasing degree of bronchial obstruction, followed by inflammatory changes beyond the narrowing Stenosis may also occur following the treatment of a bronchial carcinoma by radium. Except in the case of neoplasms, the narrowing will be concentric and, in long-standing conditions, the wall of the bronchus will show scarring and an absence of normal cartilaginous rings. Treatment consists of careful dilatation with bougies, though this is not often required after the removal of a foreign body.

Compression stenosis may be caused by enlargements of the thyroid gland, aneurysm, enlargement of the thymus gland, malignant disease of neighbouring structures including the lung, or enlarged glands in the mediastinum. Endoscopically the lumen shows a loss of the normal circular outline and may be elliptical, scabbard-shaped, or reduced to a thin crescent. It is clearly a collapsing or pressing in of the wall from outside. The mucous membrane is generally of normal colour unless a direct extension of disease is accompanying the compression. In extreme cases there may be an inspiratory collapsing of the walls due to loss of the cartilaginous support. The treatment is rarely endoscopic and clearly consists in removing the cause.

Abscess of the Lung and Bronchiectasis.

Endoscopy plays an important part in the diagnosis of lung abscess and to a lesser degree in treatment. Thus it is hoped by the bronchoscopic examination of a patient with an abscess of the lung:

(1) To exclude the presence of a foreign body;
(2) To exclude the presence of a new growth;
(3) To demonstrate the presence or absence of any stenosis;
(4) To endeavour to follow the pus to its particular bronchial source;
(5) To inject lipiodol into the particular bronchus and so help to define the abscess-cavity.

In treatment of a lung abscess, bronchoscopy is of value in so far as it helps to promote drainage. To this end the removal of a foreign body, the cauterisation of

granulations around the bronchial orifice, the dilatation of a stricture, and the aspiration of secretions which are too thick to be expectorated are most important.

In some cases it is difficult to decide which bronchial orifice is providing drainage of the abscess, and, after careful aspirations of secretions in the bronchi, *the only abnormality seen may be a slight redness of a particular opening*, and when viewed through the telescope this area of mucous membrane appears velvety. A few acts of coughing by the patient may then show pus coming from this orifice.

Bronchoscopy plays a considerable part in the diagnosis and treatment of bronchiectasis. The dilatation of the terminal bronchi produces an endoscopic picture that is characteristic. Thick viscid pus, sometimes blood-stained and often of bad odour, clings to the dry walls of the lower bronchi which are easy to enter owing to their increased size. The distribution of the disease may be confirmed by *the bronchoscopic instillation of lipiodol*, though in the case of the lower lobes this is probably more satisfactorily carried out by the oral method of introduction.

Endoscopic treatment of bronchiectasis may be summed up as follows:

(1) *The removal of mechanical obstructions to drainage* reduces the inflammatory swelling and œdema of the mucosa;
(2) The aspiration of thick viscid pus permits ciliary action, thereby facilitating better drainage;
(3) The local application by swab of medicaments such as silver nitrate 5 per cent solution, argyrol 10 per cent solution, or zinc chloride 0·1 per cent solution. Also the instillation of some oily preparation, such as gomenol, helps to protect the mucous membrane from the irritation of the pus and acts as a deodorant and diluent to the pus.

Laryngeal and Tracheal Diphtheria.

The laryngoscope and bronchoscope are of great value in differential diagnosis between diphtheria of the air-passages, asthma, and foreign body. It is also acquiring an increasing reputation in the treatment of the obstructive stage of this disease. By means of a small-sized laryngoscope in small children the diphtheritic membrane and the thick sticky secretions can be quickly and completely removed through a wide-bore aspirator. The membrane itself may require removal by forceps. In some fever hospitals the routine treatment by this method has resulted in the complete giving up of tracheotomy or intubation for laryngo-tracheal diphtheria.

Foreign Bodies.

Bronchoscopy was originally practised solely for the removal of foreign bodies. At the present time foreign-body cases constitute about 2 per cent only of the total bronchoscopies performed.

The commoner foreign bodies are teeth, small metal parts of toys, pins, and small vegetable substances such as peas, beans, and, in America, peanuts. The immediate dangers vary considerably according to the size and nature of the foreign body. Thus, a large article may be impacted in the larynx and cause rapid asphyxia, while vegetable foreign bodies quickly give rise to an intense septic bronchitis and toxæmia. If a foreign body becomes impacted in a bronchus, secondary suppuration may occur beyond it. Small metal foreign bodies may remain unsuspected for years and may cause no trouble. The right bronchus, owing to its being more nearly in line with the trachea, is invaded twice as often as the left.

Endoscopy is indicated for all cases with a foreign body and in any case where

a foreign body is suspected. X-ray examination carried out beforehand may reveal the foreign body; on the other hand, it may show only an area of obstructive emphysema due to the ball-valve action of a foreign body or an area of atelectasis due to the complete obstruction of a bronchus.

The removal of a foreign body through a bronchoscope requires a high degree of skill, necessitating much practice, and is not to be lightly undertaken by an inexperienced operator. More danger to life may be caused by prolonged and unsuccessful attempts at removal than might arise from leaving it *in situ* pending the help of an expert.

The general principles underlying the successful removal of foreign bodies are that there should be good vision of the area, that the forceps should be the most suitable for the particular object, and that as large a space as possible should be obtained at the sides of the foreign body in order to pass the forceps blade beyond it. As the foreign body is withdrawn through the glottis, care must be taken to ensure that no damage is done to the vocal cords and also to guard against the possibility of its being stripped off the forceps.

The most complete account of the mechanical problems of the extraction of various foreign bodies will be found in the writings of Chevalier Jackson and his co-workers.

Tumours.

Innocent. Innocent tumours of the larynx may be removed through the laryngoscope by means of cutting forceps or snares. As in taking a biopsy, care must be exercised to avoid any damage to the underlying structure.

Innocent tumours of the trachea and bronchi are excessively rare.

Malignant Malignant disease of the larynx may be inspected endoscopically and a portion removed for biopsy, but it is very rarely treated by this approach.

Malignant disease of the bronchus can be diagnosed only by bronchoscopy. When occurring in one of the larger bronchi, the neoplasm is clearly seen as a bleeding fungating mass obstructing the lumen. Usually, considerable sepsis is superimposed, especially beyond the obstruction. Portions may be removed for biopsy and information gathered as to situation and extent. Treatment of such tumours is now being carried out by inserting into the lumen of the growth a hollow tubular container containing radon seeds or radium needles. The insertion and removal of this container is carried out through the bronchoscope by means of special forceps (see fig. 2610). So far the number of cases treated by this method is small and no long periods of time have yet elapsed in which to observe the final results; but the immediate shrinkage of the growth and the consequent provision of better drainage to the obstructed lung beyond lead to a marked improvement in the general condition of the patient (R. C. Brock, *Jacksonian Prize Essay*, Royal College of Surgeons, 1935).

Bronchoscopy is also employed:

(1) To obtain specimens of sputum from the bronchi in suspected cases of tuberculosis where no result has been obtained by the patient's own efforts;
(2) To aspirate the viscid bronchial secretion often found after general anæsthesia, which blocks a bronchus and causes the condition of massive collapse of the lung;
(3) For the location of the site and cause of unexplained hæmoptysis; and
(4) As a part of the routine examination of the patient when thoracic surgery is contemplated.

PART XXVIII

MALIGNANT TUMOURS OF THE PHARYNX AND LARYNX

by
LIONEL COLLEDGE

MALIGNANT TUMOURS OF THE PHARYNX AND LARYNX

General Pathology

Operations for the removal of malignant tumours in the pharynx and larynx must be designed not only upon an anatomical but also upon a pathological basis, so that some account of their character and distribution is a necessary preliminary.

The great majority of malignant tumours in these areas must be classified as epitheliomata, subject to some histological variation, whilst other forms of carcinoma and sarcoma are comparatively rare.

In the oro-pharynx, epitheliomata arising on the fauces, palate and tonsil vary from squamous-celled carcinoma with many cell-nests through various grades up to the transitional-celled carcinoma in which cell-nests are absent. The grading is more important in estimating the probable response to treatment by radiation than from the surgical aspect, but it cannot be ignored in forming a prognosis and selecting a definite line of treatment. In the tonsil also the lympho-epithelioma described by Schminke occurs. This tumour consists of epithelial cells and lymphocytes intimately connected, and probably the pathological diagnosis commonly made is alveolar sarcoma, but the practical importance of its recognition lies in the high degree of radio-sensitivity which it shows. Malignant mixed tumours also occur in the oro-pharynx. These tumours are epithelial in character with a mucoid or cartilaginous stroma.

In the lower pharynx, the great majority of tumours which arise on the lateral wall, aryepiglottic folds, epiglottis, fossa pyriformis and post-cricoid area are squamous epitheliomata, but basal-celled carcinoma and papillary carcinoma occasionally occur. Other forms of malignant disease are very rare, but sometimes an innocent tumour, such as angioma, lipoma or fibroma, arises in these regions, and such symptoms as hæmorrhage or obstruction may lead to a clinical diagnosis of malignant disease.

In the larynx itself, the majority of cases are squamous epitheliomata,

but other types of carcinoma are not extremely rare. Mackenty gave the relative frequency of the different forms as follows:

Squamous carcinoma, 96 per cent.
Basal-celled carcinoma, 2 per cent.
Papillary carcinoma, 1 per cent.
Adeno-carcinoma, 1 per cent.

The last named, adeno-carcinoma, arises in the ventricle.

Endothelioma and sarcoma are encountered in the larynx in about 1 per cent of all cases of malignant disease occurring in this region. For example, 713 cases of carcinoma of the larynx were seen at the Mayo Clinic from 1910 to 1933, and only four cases of sarcoma. Soerensen has only seen half a dozen cases in his enormous experience of malignant disease of the larynx. These cases included angio-sarcoma and two cases of chondro-sarcoma. Figi records two cases of fibro-sarcoma, a fibro-myxo-sarcoma and a fibro-chondro-sarcoma. Sendziak reported all the commoner varieties, spindle-celled sarcoma, lympho-sarcoma, and alveolar sarcoma, and also the rare melanotic giant-celled sarcoma. Molinié believed that in the extrinsic parts of the larynx the epiglottis was the commonest site of origin, but it is generally intrinsic. Sarcoma on the vocal cords has been recorded, but it is most frequently sub-glottic, and may be pedunculated. Birkett recorded the successful removal by laryngo-fissure of a pedunculated spindle-celled sarcoma from the sub-glottic part of the larynx in a woman aged 22.

As a rule, sarcoma is infiltrating in character, and it is of interest that the first completely successful laryngectomy was performed by Bottini in Turin in 1875 for a mixed round- and spindle-celled sarcoma. The patient was known to have remained in good health for several years, and worked as a postman.

In surgery the anatomical distribution and manner of extension of tumours in these regions is of more practical importance than their histology, and will be described in more detail in each respective section.

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CHAPTER I

Pathology and Surgery of Tumours of the Oro-Pharynx

In the oro-pharynx, the tonsil, fauces, soft palate, or the posterior third of the tongue may be the primary site, but it is only in the early stages that the situation where the growth originated can be determined with precision.

The tonsil is the commonest situation where these growths are seen, and Norman Patterson found that of fifty cases the tonsils were involved in 70 per cent, and he states that the origin is sometimes concealed in the epithelial lining of a crypt where it can only be discovered by palpation. Dickie, on the contrary, believes that carcinoma does not *originate in the tonsil primarily*, but *at the lower part of the anterior* faucial pillar. From that situation the growth can spread quickly to the tonsil and to the side of the tongue. A frequent route of extension *is from the tonsil to the palate or in the reverse direction from the palate* to the tonsil. As soon as the tongue is reached from the lateral wall of the pharynx the extension is usually rapid, so that a diagnosis of carcinoma *of the tongue may be made. Norman Patterson considers this* an important point because he believes that a tumour which has extended *to* the tongue is more amenable to surgical treatment than one which has extended *in the opposite direction from the tongue*. The tumours which originate on the posterior third or pharyngeal portion of the tongue are of highly malignant type, and are associated with an early invasion *of the cervical glands which is frequently bilateral*, whereas epithelioma of the anterior faucial pillar does not infect the cervical glands very readily. When the uvula or the soft palate is the primary site, *the cervical glands may apparently remain unaffected* for many months, or even a couple of years, and then enlarge suddenly and very rapidly. The glands may be infected on the same side or both sides, or even *on the opposite side only. The average age of the fifty* patients mentioned by Norman Patterson was 58; the oldest was 80, the youngest 38, four were under 50; forty-eight were males, and only two were *females*.

Symptoms. In the early stages the patient complains only of discomfort in the throat and some interference with speaking and swallowing. Pain is also a comparatively early symptom, and may radiate to the neck, the ear, or the angle of the jaw. Salivation, dysphagia, fœtor, cachexia, and enlargement of the cervical glands develop as the disease progresses.

Diagnosis. The appearance is so characteristic, whether the tumour be of the ulcerative, infiltrating, or papillomatous type, that the diagnosis is usually easy, but a pre-cancerous epitheliomatosis (Bowen's disease), of which Howarth has described some examples lasting many years, may simulate epithelioma closely, and a sarcoma of the tonsil can be mistaken for a quinsy, which it may resemble unless examined by palpation as well as by inspection. In spite of this, carcinoma in this region is often mistaken for syphilis, especially if the Wassermann reaction happens to be positive. Treatment with potassium iodide and mercury produces a temporary improvement in such cases, usually at the expense of a rapidly increasing extension of the growth a little later.

As a rule, histological diagnosis should follow operation, but a biopsy may be necessary in order to establish the diagnosis of malignant disease, and it may be necessary also in order to determine the type of growth and to decide the line of treatment to be followed, because radiation is more suitable for a sarcoma or transitional-celled carcinoma than surgical treatment.

The information provided by biopsy is generally regarded as decisive, and therefore every precaution must be taken to avoid the mistakes which can easily arise if the specimen is too small or is taken from an unsuitable place. In the larynx a biopsy can be performed without risk by simply removing a piece of tissue with suitable forceps, but in the pharynx, where local conditions are entirely different, the danger of dissemination from opening blood-vessels and lymphatics, especially in cases of sarcoma, renders this method entirely unjustifiable.

Berven gives the following directions for performing biopsy in the pharynx: It should be preceded or followed immediately by radiation. If the clinical diagnosis is definite, the radiation is started at once and the biopsy is not made until the tumour begins to diminish as a result of the treatment. The patient is then given a hypodermic injection of atropine to diminish the secretion of saliva and mucus. The throat is anæsthetised by painting with 20 per cent cocaine solution, injection with novocaine being avoided. The biopsy is made at the edge of the tumour, so that a piece of healthy tissue is included. The diathermy

knife is used, activated by an apparatus producing undamped oscillations, so that blood-vessels and lymphatics are sealed. The coagulation on the surface does not spoil the histological picture. If an apparatus producing damped oscillations is used, a widespread coagulation and destruction of the tumour is produced.

Treatment. The results of treatment by radiation now show an increasing proportion of good results, but there are many growths which are not radio-sensitive, and excision by the diathermy knife is an effective method of treatment for carcinoma of the fauces, palate, tonsil, posterior pharyngeal wall, and even of the base of the tongue. The use of diathermy diminishes shock, seals off the smaller blood-vessels and the lymphatics, and destroys outlying tumour cells, so that the danger of dissemination is reduced to the minimum.

The Thermophlux P. apparatus of Siemens provides coagulation from the first and second terminals and a cutting current from the third and fourth terminals, and is a perfectly satisfactory machine. The indifferent electrode should be wrapped in a compress soaked in salt solution and applied evenly to the outer side of the thigh or the back. Even contact, avoiding air-spaces, prevents sparking and burns. In early cases, where there are no palpable glands, and where from the situation and extent of the growth there is little probability of a secondary hæmorrhage, the neck may be left alone. Such cases must be kept under observation, and if any enlargement of the cervical glands follows, the neck must be cleared by a complete dissection.

A careful inspection of the mouth and gums and extraction of any suspicious teeth must precede even the smallest operation, and another necessary precaution is to avoid any anæsthetic containing ether, which might cause an explosion. Simple excision by the diathermy knife can be performed with the aid of any gag or a suspension apparatus, but splitting the cheek does not give any better access than can be obtained by the help of vulcanite retractors. A margin of half an inch of healthy tissue beyond the visible edge of the growth should be included in the excision, and the base of the wound coagulated after the excision.

It is always impossible to exclude the possibility of invasion of the cervical glands by clinical examination, but if the growth is of an infiltrating type which requires a preliminary ligature of the external carotid to protect against secondary hæmorrhage, the lymphatic area may be cleared at the same time. If the glands are definitely enlarged they should be removed and the external carotid ligatured about ten days before the diathermy operation. After the use of diathermy, changes take place in the tissues of the neck which render the

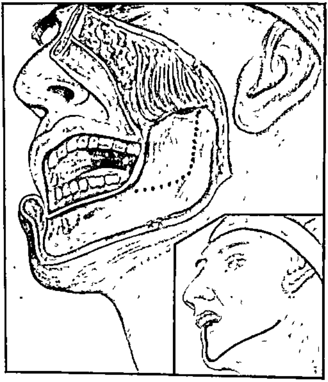

Fig. 2631.—Partial excision of the mandible for removal of a malignant tumour of the tonsil.
(*Raymond Bernart*)

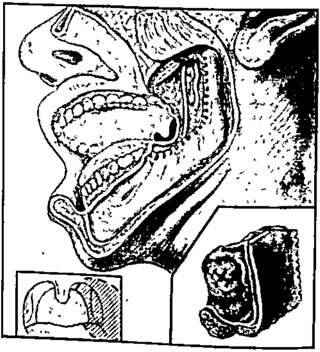

Fig 2632.—Partial excision of the mandible for removal of a malignant tumour of the tonsil.
(*Raymond Bernart*)

dissection difficult—an additional reason for attacking the neck before the primary growth.

If these reasons for tissue change and preliminary ligature are absent, theoretical considerations suggest that the primary growth should be removed first and the lymphatic glands later when cancer cells passing from the primary growth have all reached and become imprisoned in the glands, but it is doubtful if this argument is valid in practice. No special after-treatment is required, but the patient must be kept in bed until all sloughs have separated and any risk of secondary hæmorrhage has passed a period of ten to fourteen days.

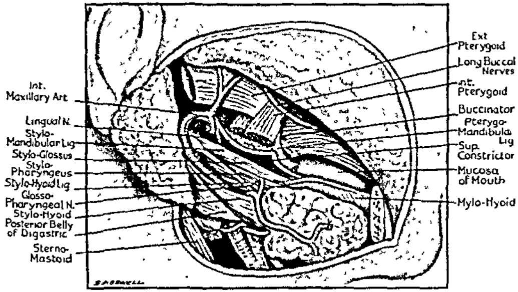

Fig. 2633.—Dissection to demonstrate the external relations of the tonsillar fossa as displayed after removal of the mandible from the condyle to the canine fossa. (*After Gordon Taylor*)

In infiltrating growths of the tonsil, where the base of the tongue or the side of the pharynx is invaded extensively, and especially if the growth has attacked and become adherent to the inner surface of the mandible and radiation has failed, a much wider exposure is needed than can be obtained through the mouth.

In a few cases a partial excision of the mandible is possible after turning up a suitable flap by an incision which splits the lower lip to the chin and extends backwards along the lower border of the mandible to its angle (figs. 2631 and 2632). A row of holes is made with a burr to mark the line of section above the attachment of the mylo-hyoid. The alveolar border and upper half of the horizontal ramus must be removed back to the vertical ramus. In this way the arch of the mandible is preserved and no direct communication is made between the pharynx and the planes of the neck.

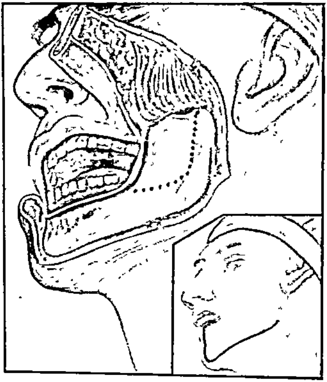

Fig. 2031.—PARTIAL EXCISION OF THE MANDIBLE FOR REMOVAL OF A MALIGNANT TUMOUR OF THE TONSIL.
(*Raymond Bernart*)

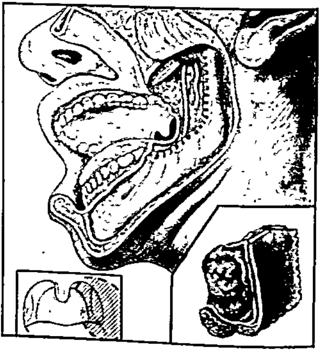

Fig. 2032.—PARTIAL EXCISION OF THE MANDIBLE FOR REMOVAL OF A MALIGNANT TUMOUR OF THE TONSIL.
(*Raymond-Bernart*)

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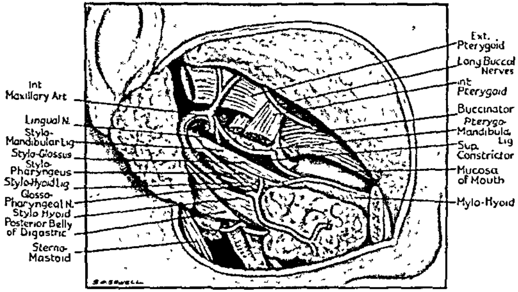

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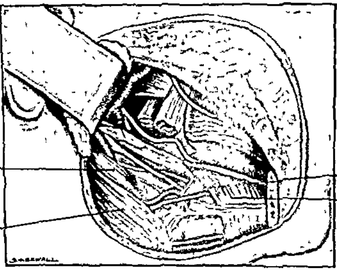

Fig. 2634.—DISSECTION TO DEMONSTRATE THE STRUCTURES INVOLVED IN A DIATHERMY EXCISION OF THE TONSILLAR AREA FROM OUTSIDE. THE MANDIBLE AND SUBMAXILLARY SALIVARY GLAND HAVE BEEN REMOVED, AND THE VASCULAR COMPARTMENT IS PROTECTED BY TURNING THE POSTERIOR BELLY OF THE DIGASTRIC AND THE *ANTERIOR BORDER* OF THE STERNO-MASTOID OVER THE VESSELS.

As a rule, the only adequate exposure is *obtained by removing the* corresponding side of the mandible from the canine fossa back to the condyle. The view obtained is shown in figures 2633 and 2634.

The *neck operation* precedes the attack on the primary tumour. The external carotid is tied and the lymphatic area cleared. No attempt should be made to preserve the *sterno-mastoid* muscle, but its remnant, with the posterior belly of the digastric and the stylo-hyoid, may be used as a protective covering for the great vessels. The jaw and growth

Fig. 2635.—CARCINOMA OF TONSIL AND SIDE OF TONGUE WHICH RECURRED AFTER TREATMENT BY RADIUM. EXCISION OF GROWTH WITH HALF THE MANDIBLE.
(*Museum, St. George's Hospital*)

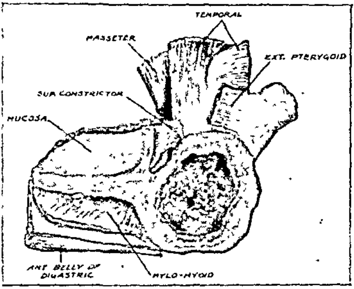

Fig. 2636.—Infiltrative carcinoma of right tonsil treated by removal of mandible and extirpation of growth and jaw en masse, March, 1923. Patient well, January, 1933.

(*After Gordon-Taylor. By kind permission of the Royal Society of Medicine.*)

are removed at a second operation when the neck has become shut off from the mouth, and the operation is completed by reconstructing the pharynx as far as possible. The extent of the removal is shown in figures 2635 and 2636, and although the operation involves a severe mutilation, large malignant tumours may be removed in this way with permanent good results.

Dickie records that in thirty cases there were seven deaths, and in fifteen cases recurrences at varying periods under five years. Eight patients had survived for more than five years, and one for over eleven years.

Gordon-Taylor has given the following convenient summary of the lines upon which appropriate treatment should be selected for each case:

Summary of Diathermy of Tumours of Oro-Pharynx

	Method of Treatment
(1) Small growth on tonsil, palate, pillars of fauces or posterior wall of larynx without glands (Group I cases).	Diathermy-excision, diathermy-coagulation, or combination of both.
(2) Larger growths with risk of a severe hæmorrhage following diathermy, no palpable glands (Group II cases).	(*a*) Preliminary block dissection of neck and ligation of external carotid. (*b*) Diathermy.
(3) More extensive growths with or without glands (Group III).	(*a*) Block dissection and ligation of external carotid. (*b*) Removal of half jaw or part of mandible, and diathermy.
(4) Doubtful tumours.	Biopsy and appropriate line of treatment: diathermy, radium, or X-rays.

Carcinoma of the epiglottis or base of the tongue requires to be considered separately although it belongs to this anatomical region.

Carcinoma in the base of the tongue, starting in the vallecula, spreads quickly into the muscles of the tongue and also travels backwards to the epiglottis and towards the aperture of the larynx. In the same way carcinoma of the lingual aspect of the epiglottis, although it remains confined to the epiglottis for many months and is relatively bemgn at this stage, spreads rapidly as soon as it reaches the base of the tongue The prognosis of such extensive tumours is very grave, they are usually resistant to treatment by radiation, and the lymphatic

Fig 2637.—Epithelioma of base of tongue and epiglottis from a man aged fifty-six.

glands on both sides of the neck become infected. A bilateral removal of these glands is an essential part of any treatment by operation. Soerensen has described a method for the extirpation of such tumours by a total excision of the larynx combined with resection of the base of the tongue, provided that the diseased part of the tongue can be removed in this way. The larynx is first exposed (see page 4886), but the pharynx is not opened below the hyoid bone. The middle of the hyoid bone is removed and the genio-hyoid and hyo-glossus muscles are cut through so that the cavity of the mouth is opened on the far side of the tumour. The tumour can then be excised together with the larynx.

If the tumour has invaded the tongue extensively and grown backwards towards the larynx, the whole tongue and larynx must be removed

together. First the larynx is freed in front and at the sides (see page 4894). Next the tongue is freed from its attachments through the mouth. The tongue is drawn forwards by its tip, the frenum is cut across, and the lingual veins are tied and divided. The mucous membrane beneath the borders of the tongue is incised as far back as the anterior faucial pillar, the palato-glossus divided, and the genio-glossus muscles then divided beneath the tongue.

The genio-hyoid and hyo-glossus muscles are then cut through just above the hyoid bone, and the lingual arteries secured between them. In this way the cavity of the mouth is reached from below, and the tip of the tongue drawn out of the wound under the jaw. The hyoid bone is then divided on either side in front of the attachment of the digastric. This allows the tongue and larynx to be drawn forward together and separated from the pharynx and œsophagus. The excision is then completed by cutting the trachea across and stitching the stump to the edges of the skin. The mucous membrane of the floor of the mouth is stitched across from the mouth, the pharynx closed from the neck, and finally the external wound is closed in the same way as in an ordinary excision of the larynx. The operation entails no particular technical difficulty and has the advantage of presenting a simple wound which can be shut off from the pharynx and mouth, and of protecting the air-passages by the suturing of the trachea to the skin.

A tumour removed in this way is shown in figure 2637.

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CHAPTER II

Pathology of Intrinsic Cancer of the Larynx

Krishaber in 1879 first proposed the classification of malignant laryngeal tumours into intrinsic and extrinsic, but any classification presents some ambiguity, because of the difficulty in drawing a precise line of demarcation between the intrinsic and extrinsic regions of the larynx, because the extrinsic areas are really situated in the cavity of the pharynx, and because some tumours which are no longer in their early stages extend into each territory and must be classified as mixed.

It is simpler to classify the tumours of the intrinsic class, which originate on the vocal cords, in the ventricle or on the ventricular band, and in the sub-glottic area, as laryngeal tumours, and to classify extrinsic tumours of the epiglottis and aryepiglottic folds as pharyngeal tumours, in which class they will be considered along with tumours of the lateral pharyngeal wall, sinus pyriformis, and post-cricoid area. There are more than purely anatomical reasons for this, because the symptoms, the lymphatic drainage and the principles which must govern attempts at surgical treatment of tumours in the extrinsic group are all in the *domain of the pharynx rather than of the larynx.*

Felix Semon recorded that in twenty-eight years of practice he had seen 212 cases of laryngeal cancer, of which 136 were intrinsic and 78 were extrinsic or mixed. It is probable that different observers would see various types of cases in different proportions, according to the type most frequently referred to them individually, but these figures agree roughly with those given by Schmiegelow and others and probably give a fairly correct idea of the relative incidence.

Maxwell and Hogg from a statistical study of all forms of laryngeal cancer, extrinsic and intrinsic combined, have shown that since 1911 the absolute increase in mortality from this cause has been almost three-fold, and also that the proportion of laryngeal in relation to all forms of cancer has risen from 1·29 per cent to 1·92 per cent. As this only refers to fatal cases and many are now saved, the real proportion is probably still higher, especially as in malignant disease of the œsophagus and tongue, where the prognosis is bad, the figures have fallen respectively from 4·05 to 3·90 and from 2·72 to 2·09 per cent.

Of all the factors concerned in the ætiology of laryngeal cancer, sex and age are the only ones in which definite information is available.

In a series of 105 cases of intrinsic cancer submitted to operation there were eleven females. This incidence of 10 per cent in females is of importance because the diagnosis is sometimes missed on account of the mistaken idea that the disease does not occur in the female sex. The same holds good for the extrinsic or pharyngeal parts of the larynx, except in the post-cricoid region where the position is reversed. In a group of 96 cases of post-cricoid cancer collected by Logan Turner there were 13 males and 83 females. The statement that cancer of the hypopharynx is more frequent in females applies only to this group of cases in the post-cricoid area.

The following table compiled by Tapia from his vast experience of cancer of the larynx shows that the great majority of cases occur in the two decades from 45 to 65, and that the condition is commonest between 50 and 60.

Age.	20-25	25-30	30-35	35-40	40-45	45-50	50-55	55-60	60-65	65-70	70-75	75-80	Total
Cases.	1	9	18	53	125	206	211	179	116	58	10	3	979
										Not recorded			14
													993
Percentage	0 1%	0 9%	1 8%	5 3%	12 5%	20 6%	21%	17 7%	11 6%	5 8%	1%	0 3%	

Jurasz found that sarcoma as well as carcinoma is commonest between 40 and 60, but it sometimes occurs in quite young people. It is more remarkable that this is true also of carcinoma, apart from the post-cricoid growths which occur in young women. Figi and Gordon New have recorded cases of intrinsic cancer in a youth of fifteen and a woman of twenty-four, both cases being treated by laryngectomy. Garel saw an intrinsic case in a girl of eighteen and Chiari one in a girl of sixteen. Portmann and Philips collected a number of cases in young people and described one of intrinsic epithelioma in a girl aged 12. Still more remarkable is the case described by Lemaître of a girl aged 8 in whom treatment by X-rays produced radio-necrosis and converted a laryngeal papilloma into a papillary epithelioma.

In this last case the irritation and scarring caused by the treatment acting upon a soil already predisposed was no doubt an important ætiological factor, and Lumière has gone so far as to attempt to prove

that all cancers arise in scar tissue. The observations of Slosse and Reding on the alkalinity of the blood suggest that there is a general factor concerned also, but that epithelioma sometimes, if not always, arises in scar tissue is beyond doubt.

Denker has related an extraordinary case of *Narben carcinoma* in a man aged forty who was brought to the clinic on account of severe stenosis of the larynx. He had attempted suicide twenty years before by cutting through his larynx with a razor. The wound healed eventually, leaving some difficulty in breathing, but he was able to do light work. For the last three months the difficulty in breathing had increased. There was a scar on the front of the neck firmly adherent to the cricoid cartilage. The vocal cords were almost fixed in the middle line and appeared heavily infiltrated and thickened. After a low tracheotomy a piece of tissue removed for examination showed carcinoma. When total laryngectomy was performed it was found that the trachea was extensively invaded with growth, and the upper part of the trachea was resected in addition. The patient recovered after a stormy convalescence complicated by a secondary hæmorrhage. From the subsequent examination of the larynx Borst considered that the cancer definitely arose from the scar tissue The patient ultimately left the hospital having gained forty-five pounds in weight After he returned home his sister hanged herself, and he himself, in another attack of melancholia, shot himself on the grave of his sister.

Chevalier Jackson considers vocal abuse an important factor in the ætiology. In an experience of 582 cases of proved cancer of the larynx there had been undoubted vocal abuse in 376 cases (64·6 per cent). One half of these 376 persons were professional voice users, including public speakers, teachers, singers, salesmen and drill-masters, besides mechanics and hands employed in noisy and dusty factories. He regards this abuse of the voice as a common cause of chronic laryngitis, keratosis, papilloma and granuloma, which form a favourable soil for the development of cancer.

Chronic laryngitis caused by poisoning with mustard gas during the war was followed by cancer after persistent hoarseness lasting four years in an officer aged forty-two. Douglas Guthrie also has recorded the case of a soldier who remained hoarse for six years after being gassed. Epithelioma then supervened. The patient was treated by laryngectomy and has remained well for ten years. In these exceptional cases the connection between cause and effect can scarcely be doubted, but the usual effect of gassing upon the vocal cords is the production of papillomata and granulomata.

Syphilis is sometimes regarded as an important predisposing cause. There is sometimes a history of syphilis, and occasionally a preceding syphilitic lesion in the larynx, but this is certainly quite uncommon.

It is possible that tobacco is an important factor in the ætiology,

although the disease occurs in non-smokers also. Tapia believes tobacco to be the most important factor in the ætiology of laryngeal cancer. Its rarity in the female sex indicates some external influence acting on the male larynx. Four of the six women in his own 993 cases were smokers, and in Spain smoking is rare amongst women. Those who do smoke seldom inhale.

In contrast to this, Hernando Segui of Havana encountered 13 cases in Cuban women amongst 75 patients with laryngeal cancer. All the thirteen were heavy smokers. From the histories of his own cases Tapia found that all the patients were cigarette smokers and that they all inhaled. Cigar smokers do not inhale, and he agrees with Hernando Segui that cancer is more frequent in cigarette smokers than in cigar smokers.

In the great majority of cases intrinsic cancer first attacks one vocal cord. The anterior or middle third of the cord is almost invariably the primary site. The posterior third of the cord or posterior commissure is rarely if ever the site of origin, but in one exceptional case which came under observation epithelioma supervened upon pachydermia of four years' duration in this situation. When the case is first seen, however, the anterior two-thirds or the whole of the cord may be affected, because the main line of extension is along the length of the cord. The extension tends to spread forwards rather than backwards so that the anterior commissure is soon reached by a growth situated on the anterior third, whereas once the attachment of the cord to the vocal process of the arytenoid cartilage is reached in the process of extension backwards further progress towards the posterior commissure is slow. Consequently when the growth crosses to the opposite side it almost invariably does so at or below the anterior commissure. In one exceptional case an epithelioma was found to have formed a complete ring round the interior of the larynx at the level of the glottis, but, as a rule, even if the growth has become very extensive the posterior commissure is the part least invaded. As Jobson Horne pointed out, tubercle attacks by preference the posterior part of the larynx where the epithelium is columnar and contains glands, while epithelioma attacks the anterior part where the epithelium is squamous and free from glands.

This linear extension along the vocal cord is well illustrated by an observation of MacKenty. A total laryngectomy was performed on three patients with early cancer, although the apparent indication was for laryngo-fissure. In two of these, microscopic examination showed extension below the surface up to and into the angle of the anterior commissure.

In the third case the extension beneath the surface went forwards

and backwards, undermining the entire extent of the cord. It is impossible not to draw the conclusion that great caution must be exercised in selecting cases for conservative operations, and some observations by Gordon New confirm this:

"The microscopic extension of different grades of carcinoma of the larynx was studied in a hundred specimens taken at laryngectomy in the last six years. . . . Sections were first made at 5 mm. from the apparent margin of the growth. If carcinoma was found at this point, then sections were made at 10 mm., and if these were found to be malignant, sections were taken at 15 mm. from the apparent margin of the growth. The maximal extension of highly malignant carcinomata from the apparent margin of the growth was 15 mm.; in low-grade carcinoma the extension was not found further than 5 mm. from the apparent margin of the growth. The average degree of extension of the various grades of carcinoma revealed that in carcinoma graded 1 there was no extension, in carcinoma graded 2 there was extension of 5 mm., in carcinoma graded 3 there was extension of 5·9 mm., and in that graded 4 there was extension of 5·6 mm. The fact that the carcinomata graded 4 did not extend further locally may be due to their tendency to enter the lymphatic channels early without much local extension; thus with a small primary growth there may be extensive metastasis. In one of our cases the carcinoma was a small local growth which metastasised early, and death occurred in five months. The specimen removed did not reveal local extension. The average extension of all grades of carcinoma was 5·5 mm. It is generally believed that in performing laryngo-fissure for carcinoma an excision about 0·75 cm. from the apparent margin of the growth gives a fair margin of safety. In many of the specimens we observed such excision would have been made into the growth."

Further support for the contention of MacKenty that laryngo-fissure is only suitable for the earliest cases is supplied by an observation made by Benjamin. The histological examination in serial sections of a vocal cord removed by hemilaryngectomy showed the presence of several small separate cancers. The tumour had developed from several centres in close proximity, as has been shown to occur experimentally in the production of tar cancer. In this case the tumour had developed insidiously in the cord without evident signs of tumour formation. In consequence, the opinion that has been expressed by Soerensen and by

MacKenty that *more than one separate primary growth does not occur* in the larynx, but that apparent multiplicity is due to outcropping to the surface from lymphatic extension, must be accepted with reserve. In practice it is not extremely rare to find a second apparently primary growth or occasionally a contact epithelioma on the opposite cord.

If the growth has extended from the edge of the cord to the sub-glottic region, or is sub-glottic in origin and has attacked the cord from below, it may cross to the opposite side below the anterior commissure and reach the opposite cord also on the under-surface, so that the *tumour may be far more extensive in such circumstances than appears* from laryngoscopic examination. Tumours at the anterior commissure

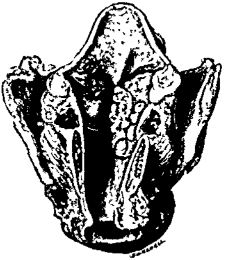


Fig 2638.—Epithelioma of vocal cord which has become sub-glottic, has extended back to the arytenoid, forward to the middle line, and has invaded the base of the epiglottis Laryngectomy (*Museum, St. George's Hospital*)

Fig. 2639 —Epithelioma of vocal cords, in a woman, with unusual extension backwards to arytenoid and cricoid cartilages The pressure on the pharynx caused dysphagia. Laryngectomy.

also infiltrate the base of the epiglottis insidiously, so that it is a good rule invariably to remove the epiglottis with the rest of the larynx at the operation of complete laryngectomy (fig. 2638).

Growth which has reached the sub-glottic region or taken origin there may sometimes continue to spread downwards until the upper part of the trachea is reached. It is, however, especially liable to perforate the anterior part of the larynx through the crico-thyroid membrane and so reach the lymphatic gland which lies there, and then invade the pre-laryngeal muscles. Less commonly it burrows through the ala of the thyroid cartilage in numerous small holes, but this is much less common as the cartilage usually offers an impassable barrier to further spread in that direction until the later stages, when a gross invasion may be the cause of perichondritis.

The cricoid cartilage is still less commonly attacked, but figure 2639 shows the larynx from a woman in whom, in addition to the hoarseness, dysphagia was a much more prominent symptom than dyspnœa, and this was due to the tumour spreading in the arytenoids and the plate of the cricoid cartilage and producing pressure on the pharynx.

Attention must also be called to a small group of lymphatic glands lying under the upper edge of the isthmus of the thyroid gland. These may be invaded relatively early, and if overlooked explain some unexpected recurrences in the tracheal stump after laryngectomy, and also the occasional and unexpected discovery of growth in the thyroid gland at operation.

Much less commonly than on the vocal cord, cancer originates on the ventricular band or in the ventricle of Morgagni (fig. 2640).

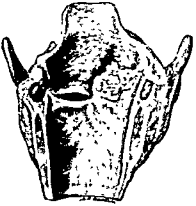


Fig. 2640.—Epithelioma originating in the ventricle and invading the vocal cord and ventricular band. Laryngectomy. (Museum, St. George's Hospital.)

Schmiegelow found that in a series of sixty cases of intrinsic cancer the origin was twice in the ventricle of Morgagni and five times on the ventricular band. In a series of one hundred and twenty-five cases seen in the clinic of Hautant during a period of six years there were twelve such cases, one in a woman and eleven in men. In this situation the tumour is sometimes an adeno-carcinoma, and the extension upwards towards the pharynx and base of the epiglottis is more rapid than in epithelioma of the cord, which tends rather to extend downwards.

An important group of cases, which may even be classified under a third sub-division, as Isambert proposed in 1876, are those which arise in the sub-glottic area. Butlin recorded five such cases in fifty cases of laryngeal cancer of all kinds, so that the sub-glottic situation, apart from extension downwards from the cord, is uncommon. The origin may be on the lower surface of the cord below its free margin, which remains intact until the growth extends upwards, or the origin may be below the cord altogether, as low as the cricoid ring, but in either case it is always in the anterior half of the larynx.

The lymphatics along the internal jugular vein become affected much later in the intrinsic group of cases where the tumour takes origin on the edge of the cord. It may be that at this level, which forms a lymphatic watershed between the upper and lower divisions, lymphatics are few and the lymphatic drainage is very restricted, or it may be that this area is remote from the lateral boundary and imprisoned in a cartilaginous cell, or it may even be simply a characteristic of the type of epithelioma which occurs here, but it is a clinical observation of great importance.

It is, however, one upon which too much reliance must not be placed, for as the growth spreads the cancer cells from the upper area eventually pass into the lymphatics which cross the fossa pyriformis behind and the thyro-hyoid membrane in front, and reach the gland situated in the angle between the common facial vein and the internal jugular vein. *From the lower area the lymphatics pass through the crico*-thyroid membrane to glands in front of the larynx, and thence to the deep cervical glands upon the internal jugular. Consequently, in cancer *of the ventricular bands and in sub-glottic cancer, invasion of the cervical* lymphatic glands occurs earlier than in cancer of the vocal cord, and in the operation of laryngectomy for intrinsic cancer freedom of the lymphatic glands from growth must never be assumed, but the region of the carotid bifurcation in particular must be carefully searched.

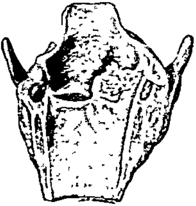
When the tumour originates on the free edge of the vocal cord the only symptom is hoarseness, often attributed by the patient to a cold or a sore throat, but the date of the onset may be very vague, and failure of the singing voice may be an early symptom. A small tumour on the edge of the cord near the anterior commissure will cause more interference with the voice than a larger growth further back or embedded in the substance of the cord, because the growth is so situated as to prevent closure of the glottis, so that hoarseness and vocal fatigue will soon become pronounced.

This stage usually lasts many months, but as the growth progresses the voice becomes weaker and as the glottis narrows dyspnœa and stridor develop. Even so, the general condition does not usually deteriorate if the dyspnœa is relieved by tracheotomy until a further spread causes perichondritis, enlargement of the cervical glands, and involvement of the pharynx itself. There is then, in addition, pain in the ears, fœtor and salivation, dysphagia, with cachexia and wasting. These last symptoms indicate only a terminal and hopeless stage of the *disease. The characteristic symptom at an early stage, when it should* be diagnosed and can be treated with success, is hoarseness.

The cricoid cartilage is still less commonly attacked, but figure 2639 shows the larynx from a woman in whom, in addition to the hoarseness, dysphagia was a much more prominent symptom than dyspnœa, and this was due to the tumour spreading in the arytenoids and the plate of the cricoid cartilage and producing pressure on the pharynx.

Attention must also be called to a small group of lymphatic glands lying under the upper edge of the isthmus of the thyroid gland. These may be invaded relatively early, and if overlooked explain some unexpected recurrences in the tracheal stump after laryngectomy, and also the occasional and unexpected discovery of growth in the thyroid gland at operation.

Much less commonly than on the vocal cord, cancer originates on the ventricular band or in the ventricle of Morgagni (fig. 2640).



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When the growth takes origin on the ventricular band or is confined in the ventricle, early symptoms may be absent and the voice may not be affected until the tumour has reached sufficient size to cause the sounds to be a little muffled. On the other hand, there is more likely to be local discomfort and irritation, and pain referred to the ear. As soon as the tumour ulcerates, it quickly encroaches on the glottis and causes dyspnœa. In sub-glottic cancer the early symptoms may be very obscure, no more than some discomfort and difficulty in clearing the throat. Slight dyspnœa and stridor on exertion may be the earliest definite symptoms, unless one cord has been attacked from below, when its lack of mobility may cause changes in the voice. Hoarseness develops later when the edge of the cord is reached.

Diagnosis. The diagnosis of malignant disease has to be made from chronic laryngitis, pachydermia, submucous hæmorrhage, innocent tumours, paralysis, keratosis, syphilis and tuberculosis.

Laryngitis affects both cords, whereas a unilateral congestion suggests either early tuberculosis or malignant disease. Pachydermia affects the posterior segment of the larynx, and the cup-and-ball formation at the attachment of the cords to the vocal processes is characteristic, but may be difficult to distinguish in the early stage. In one case under observation epithelioma supervened upon pachydermia of at least four years' duration, but this sequence is very rare.

A cook under the influence of alcohol fell against the edge of the kitchen table and sustained a blow on the larynx which produced a hæmorrhage into the substance of one vocal cord. The appearance of the cord, combined with its partial fixation, perfectly simulated an epithelioma, but the history of the case and the gradual absorption of the hæmatoma precluded the possibility of any mistake in diagnosis.

The diagnosis of innocent tumours depends largely upon microscopic examination after removal, but the difficulty in distinguishing between paralysis of a vocal cord and malignant disease is sometimes greater than might be expected. On the one hand, a sub-glottic tumour, which is quite concealed below the cord, may cause such mechanical limitation of movement that the cord appears paralysed, and, on the other hand, a common error is to mistake the apparently unilateral swelling at the back of the larynx, caused by the prolapse forwards of the corresponding arytenoid cartilage in recurrent laryngeal paralysis, for a tumour. Familiarity with this appearance, with which lack of tension in the cord is combined, should prevent this mistake.

Malignant disease in the ventricle may cause great difficulty, because at first it is quite concealed, and later shows only by a bulging which

may be mistaken for prolapse of the ventricle. When it eventually reaches the surface and ulcerates, the ulcer has to be distinguished from a syphilitic or tuberculous ulceration, especially the latter. Points to remember are that in this variety of malignant disease the cervical glands may enlarge early, and that in tuberculosis multiple lesions are common.

The real difficulty is presented by keratosis, syphilis, and tuberculosis. The appearance of early malignant disease of the vocal cord is variable. It may be a unilateral congestion with slight thickening of the cord scarcely to be distinguished from incipient tuberculosis, it may take the form of papillomatous outgrowth, it may be an irregular infiltration, or it may show as a characteristic epithelioma with a raised edge. In the early stages the cord remains mobile, and continues to do so until there is some infiltration of the underlying muscles, but usually the mobility is impaired sooner than in tuberculosis relative to the extent of the disease. Loss of mobility or the reverse is not a sign on which much reliance is to be placed, for St. Clair Thomson noted than in a series of seventy early cases suitable for treatment by laryngo-fissure the cord affected was still quite mobile in thirty-nine. In all cases the Wassermann test should be applied, the chest examined, and the sputum tested for tubercle bacilli if there is any cough. Even this does not necessarily settle the diagnosis, because in a case of malignant disease the Wassermann test may be positive or an X-ray film may show a lesion in the chest. The tendency is therefore, especially in view of the great number of erroneous diagnoses which have been made in the past, to rely upon a biopsy for confirmation of the diagnosis.

The disease which causes mistakes is tuberculosis far more often than keratosis or syphilis. If keratosis is mistaken for epithelioma it is not of much consequence, as it is better to remove a cord which is the seat of a persistent patch of keratosis. Syphilis can usually be excluded by the Wassermann test and the administration of mercury and potassium iodide, because it is the relatively early and active lesions which produce the appearances resembling cancer, rather than the late tertiary infiltrating lesions which are sometimes associated with a negative Wassermann test.

There is, however, a type of chronic tuberculous lesion which remains confined to one or both vocal cords and is not uncommon in the middle-aged and elderly. In this form of tuberculosis there may be no sputum, physical signs in the chest may be absent or equivocal, and even a skiagram shows only an old inactive apical lesion.

Nevertheless, a piece of tissue removed from the cord for biopsy may show characteristic giant-cell formation and tubercle bacilli.

When malignant disease is more advanced and has caused fixation of the cords, stenosis of the larynx and a broadening which can be felt externally, the diagnosis is usually easy, but it is the early diagnosis which is both difficult and important It may be necessary to examine the larynx more than once in a doubtful case, especially in sub-glottic cancer, but oft-repeated examination (as has been advised) allows the disease to progress and undermines the confidence of the patient. It is much better then to resort to biopsy if doubt remains after a complete clinical examination. Biopsy does not here carry the same risks as in the pharynx, œsophagus, and elsewhere, it does not appear to stimulate the growth greatly, and there is no definite evidence that it produces metastasis, though a positive result should be followed by excision of the growth as soon as possible The words of Newman, however, are to be remembered:

> "Intralaryngeal excision for microscopic purposes exposes the patient to very serious dangers by increasing the rapidity of secondary new formations. The incision of a cancerous growth or its partial removal has justly been regarded as a most dangerous procedure, probably because the absorption of the infective material takes place rapidly from a wounded surface. While conscious of the value of removing portions of a laryngeal neoplasm for diagnostic purposes, I desire to express my strong conviction that it should not be resorted to in cases suspected to be cancer unless the patient is willing to have a radical operation performed immediately after the diagnosis is completed."

Those accustomed to the use of laryngeal forceps by indirect laryngoscopy may employ this method, but it is only possible to remove portions of projecting growths, and the objections formerly raised were against biopsies performed in this way. It is better to remove the specimen by the direct method, using an anterior commissure laryngoscope and Jackson's basket-shaped tissue forceps, the male blade of which can be thrust deeply even into a flat infiltration. This method rarely fails to provide a specimen which gives definite information microscopically, and the task is accomplished with the least possible damage. It must not be forgotten, however, that misleading pathological reports are not unknown, and in forming a final diagnosis the report must be checked carefully and the clinical aspect taken fully into account. Removal of an enlarged gland, an indirect method of biopsy, is sometimes capable of yielding useful information.

CHAPTER III

Surgery of Intrinsic Cancer of the Larynx

Treatment aims at the removal of a malignant growth surrounded by a sufficient margin of tissue to include microscopic extension beyond *the apparent limits of the tumour. The extent of the growth, so far as* it can be determined before it is exposed at operation, will decide whether this removal can be accomplished by splitting the larynx and excising the tumour, or whether a partial or total excision of the larynx is required, though certain other points may have to be considered also. Naturally, a conservative operation which will allow preservation of the voice is to be preferred if it is sufficiently extensive for the particular case, but this consideration must not outweigh the primary need for choosing a sufficiently radical operation. Many conservative operations have been followed by recurrences, which need not have occurred if the necessity for a more radical excision had been realised. The extent of the primary growth is here some guide also in deciding whether the cervical lymphatic glands are likely to be invaded and whether the operation should include their exploration and removal, apart from obvious and palpable enlargement before operation. In some situations, such as the pharynx, the extent of the primary growth seems to have no definite relation to the extent of the glandular enlargement, and it often appears to be in inverse proportion; but *inside the larynx the situation and extent of the primary tumour* is a fairly reliable guide. The observations of Gordon New on this point, bearing on the grade of the tumour, are here pertinent (see page 4858).

The cases most suitable for laryngo-fissure are those in which one cord only is affected, and this is freely mobile and free from disease at either end. If the disease has extended to the anterior end of the cord but has not crossed the middle line, this method is still applicable provided the section passes strictly through the middle line or even somewhat towards the sound side.

If the disease has crossed the anterior commissure, then partial laryngectomy, which includes the front of the larynx, is the least radical operation which is applicable. When the disease has crossed to the opposite side by first dipping down into the sub-glottic region

and then passing across below the anterior commissure, or if the disease crossing the anterior commissure has at the same time invaded the base of the epiglottis, a partial laryngectomy may be considered, but in such cases it will generally be found that a total laryngectomy is required.

When the disease is limited to one cord, its mobility is a factor which must be assessed in deciding whether laryngo-fissure is indicated. Impaired movement indicates that the muscles have become infiltrated at some distance from the surface, and its importance is shown by an analysis of 66 cases by St. Clair Thomson. In 37 cases the cord was freely mobile and 31 were free from recurrence three years after the operation (84 per cent). In 20 cases the movement of the cord was impaired and 15 passed the three-year limit (75 per cent). In 9 cases the cord was quite fixed and only 4 cases passed the three-year limit without recurrence (44 per cent).

Fixation of the cord must therefore be taken as a general indication that laryngo-fissure is not suitable. If exception is made to this rule it must be on the ground that a biopsy has shown that the growth belongs to Group I in Broder's Classification. The successful cases of laryngo-fissure in the presence of a fixed cord almost invariably owe their freedom of recurrence to the low grade of malignancy. One of the most rapid recurrences which occurred in the series just mentioned followed in a few weeks on a laryngo-fissure for a tumour subsequently graded as belonging to Group IV.

Extension backwards to the vocal process of the arytenoid cartilage, and any considerable sub-glottic extension contra-indicate laryngo-fissure because this operation does not allow the tumour to be removed with a sufficient margin posteriorly. Tumours originating below the glottis are unsuitable for laryngo-fissure, for this operation has almost invariably failed to provide a successful result in sub-glottic cancer. In a few cases, where the growth occupies the anterior part of the larynx and is situated at the commissure and upon both vocal cords, the operation of laryngo-fissure can be varied by dividing the thyroid cartilage to either side of the middle line, thus removing the front of the larynx with the underlying growth. This operation, in which the front of the cricoid ring can be included, provides a radical cure without causing stenosis of the larynx and leaves the patient with a useful voice. It has on two occasions provided freedom from recurrence for 5 years and 3 years in cases referred on account of recurrence after laryngo-fissure. Tapia has described this as "anterior hemilaryngectomy."

Other forms of partial laryngectomy are not very satisfactory, and Soerensen shares the view that the indications for partial resection of

the larynx are very restricted on account of the difficulty in excising the tumour with an adequate margin of sound tissue and in the plastic reconstruction of the larynx.

On the other hand, Trotter considers that it is open to controversy whether the whole larynx should ever be removed, and that without diminishing the chances of recovery it is frequently possible to leave a half or one-third of one cord, or even one arytenoid, whilst removing the rest of the larynx. By lining the raw surface with skin he claims that a good voice is preserved and the danger of the operation much diminished.

The danger of local recurrence, for which the poor functional result obtained by the plastic operation does not compensate, lends much support to the opinion of Soerensen. In addition, many of the patients are compelled to wear a tracheotomy tube permanently on account of stenosis.

Nevertheless, the effort to preserve the functions of the larynx without additional risk to the patient, either of local recurrence or from the immediate effects of the operation, is in the true spirit of surgery. Of such efforts, one of the best is the method of hemilaryngectomy designed by Hautant to provide a rather more extensive excision than can be obtained by laryngo-fissure. Nevertheless, the results are remarkably similar to those already mentioned as recorded by St. Clair Thomson. In 65 cases submitted to this operation there were 2 post-operative deaths, and in 21 cases recurrence. Further, if the cases were divided into three groups with (1) mobile cord, (2) cord slightly mobile, and (3) cord fixed, it was found that in the first group there were 14 cases without any recurrence. In the second group there were 21 cases with 2 post-operative deaths and 1 recurrence. In the third group, where one-half of the larynx was quite fixed, there were 30 cases with 18 recurrences, that is, 60 per cent.

It appears, therefore, that the operation does not justify itself by the results in the third group of cases, and it is just in that group that some operation less mutilating than laryngectomy would be desirable, if it could provide the same security against recurrence. *It is in this group also that radium fails with consistent regularity.* It is impossible, therefore, to escape the conclusion that, in cases which are too advanced for radical treatment by laryngo-fissure, the tendency for the growth to cross the middle line below the anterior commissure and to attack the crico-thyroid membrane or to invade the base of the epiglottis makes the indications for partial resection of the larynx very limited, and that such cases should generally be treated by total laryngectomy. The observations of MacKenty and of Gordon New on the microscopic

extension of carcinoma in the larynx beyond the apparent limits of the growth lend strong support to this view (see page 4857).

Laryngectomy is indicated for intrinsic cancer in the following conditions:

(1) When the tumour has extended forwards into the epiglottis, or backwards to the arytenoid cartilage.
(2) If it has crossed to the opposite side below the anterior commissure or if there is more than a trifling sub-glottic extension.
(3) When the ventricular band is attacked, or there is evidence that the tumour has originated in the ventricle of the larynx.
(4) When the thyroid cartilage or the crico-thyroid membrane is invaded.
(5) When one cord is fixed, with the possible exception in the case of tumours classified in Grade I, or if both cords are fixed.
(6) In cases of recurrence after laryngo-fissure, a partial laryngectomy may occasionally succeed (see page 4866), but laryngectomy is usually indicated.

In 12 patients who had previously undergone the operation of laryngo-fissure and were treated for recurrence by laryngectomy the results were as follows: 5 died within a year from further recurrence, 1 died from heart disease clinically free from any sign of cancer, and 6 remain well, one for 11 years, one for 8 years, two for 6 years, one for 5 years and one for 2 years, since the laryngectomy. In the last of the twelve, a patient who died in 1931, the disease had recurred very quickly after the laryngo-fissure, and it was reported to have recurred a second time within a few months following the laryngectomy in the lower end of the scar from the laryngo-fissure. Thus, including the 2 cases already mentioned, treated by partial laryngectomy, 14 patients have undergone secondary operations for recurrence after laryngo-fissure with a further recurrence in 5, while 8 remain alive and well. Soerensen records that in 125 cases treated by laryngo-fissure, with 6 deaths, there were 9 recurrences, and of these patients 4 were cured later by total laryngectomy.

Gluck and Soerensen in the enormous number of cases treated in Gluck's clinic had one series of 72 cases without a death. In 44 private patients treated personally by laryngectomy there were 3 deaths from the operation, and amongst the first 24 of these cases 15 have remained well and free from recurrence for periods between 5 and 15 years and several have died from other complaints. Patients treated in hospital have given less favourable results owing to the technical difficulties, changes of staff, and poor condition of many of the patients.

CHAPTER IV

Partial Resection of the Larynx

LARYNGO-FISSURE

In the preparation of the patient, abstinence from alcohol and the reduction of excessive smoking for several days beforehand are valuable in reducing congestion and bleeding during the operation. The treatment of the mouth need not be so drastic as is necessary before laryngectomy or pharyngotomy, but this does not mean that it may be neglected, and all loose teeth should be removed not less than ten days before the operation. The wound does not come into contact with mucus and saliva from the mouth, so that there is not the liability to sloughing which occurs after operations on the pharynx if raw surfaces are left exposed.

The operation is often performed under local or regional anæsthesia only, but combined general and local anæsthesia spares both the patient and surgeon a formidable ordeal and has proved satisfactory.

The line of the incision from the hyoid bone to the jugulum is infiltrated with novocaine solution, containing not more than 1 in 10,000 adrenalin. If eudrenine, which contains β-eucain and answers very well, is used, not more than 3 cc. should be injected, as any excessive quantity of adrenalin interferes with healing, but almost any quantity of 2 per cent novocaine may be used without danger. The general anæsthetic of chloroform or of chloroform and ether can then be quite light, as the local anæsthetic abolishes the reflexes from the skin of the neck, so that incision and manipulation of the skin produce no reflex movements.

All preliminary medication, so-called basal anæsthetics, and especially anæsthetics administered by the rectum, should be strictly avoided. These may have some advantages in abdominal surgery, but in operations on the larynx and pharynx nothing can replace a skilful anæsthetist who will keep the patient at a steady level of anæsthesia from which he can recover rapidly with a cough reflex present at the end of the operation.

The patient is placed in the position for tracheotomy, lying supine with the shoulders raised by a flat sand-bag so that the head can be

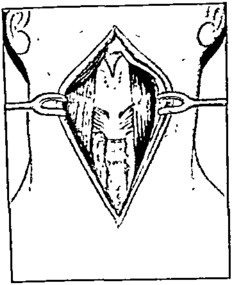

Fig. 2641.—Laryngo-fissure. The front of the larynx and trachea cleared, and the thyroid isthmus divided.

well extended with the larynx and trachea thrown forward. The head should be fixed in this position by a pair of sand-bags and kept strictly in the median position throughout the operation, so that the larynx is split exactly through the anterior commissure. The shoulders must be placed and retained at the same level.

The incision from the hyoid bone to the jugulum divides skin and fascia, and if the local anæsthetic has been given fifteen or twenty minutes to take effect there is no bleeding from the skin. The pre-laryngeal and pre-tracheal muscles are separated in the median line and held apart with retractors, exposing the isthmus of the thyroid gland. A few veins crossing the middle line obliquely sometimes require to be divided between two ligatures to obtain a good exposure. The thyroid isthmus should be freed by cutting the fascia attached along its upper

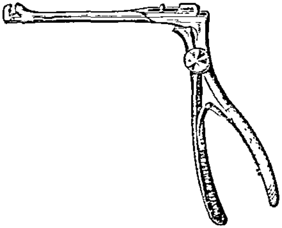

Fig. 2642.—Hajek pattern of punch forceps.

edge and separating it from the trachea with a blunt dissector (fig. 2641). The isthmus can then be clamped and divided, but the only vessel which is usually liable to bleed is one which runs along the upper border. This vessel should be underrun with a ligature on a needle and tied on either side. The trachea, cricoid and thyroid cartilage are then cleared up to the notch, taking care not to denude the cartilages of the external perichondrium. A few drops of 2 per cent solution of cocaine injected into the trachea with a hypodermic syringe, so that the liquid falls upon the posterior wall, will render the trachea insensitive and prevent unnecessary coughing and straining when the tracheotomy tube is inserted.

Whilst the cocaine is taking effect, all bleeding points are tied. The bleeding is usually entirely venous and comes from branches of the anterior jugular, veins in the capsule of the thyroid gland, and superficial veins in the fascia beneath the skin.

When the wound is perfectly dry the trachea is opened by cutting away the front of the third or fourth ring. The simplest way is to divide the membrane above and below the ring and then to cut away the middle of the ring with a Hajek sphenoidal punch or Citelli forceps. A clean piece can thus be clipped out whether the cartilage is calcified or not. This opening will then receive a Durham tube without the pressure and damage caused by inserting the tube through a slit. If it is not big enough the centre of an adjoining ring above or below can be clipped away in the same manner. The anæsthetic is now continued by administration through the tracheotomy tube.

Either before the trachea is opened or at this stage the thyroid cartilage is divided in the middle line with a Hey saw or a small saw provided with a bayonet handle which will clear the chin (see fig. 2643). It is easiest to do this standing behind the head of the patient. The cut need not pass through the whole thickness of the cartilage, and in women it is so soft that no saw-cut is needed at all. The crico-thyroid membrane is then divided, and the lower blade of Irwin Moore shears introduced into the larynx between the vocal cords from below and pushed home until the lower edge of the cartilage lies against the angle between the blades (see fig. 2645). One cut with the shears, keeping scrupulously to the middle line along the saw-cut, will then divide the cartilage completely, and only a few touches with a knife are necessary, to divide strands of soft tissue, so as to allow the larynx to be opened. In women, in whom the larynx is small and when opened provides a cramped field for operation, a better exposure is obtained by dividing the cricoid also in the middle line. The cartilage is soft and yielding

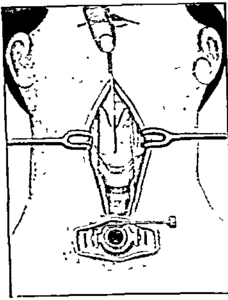

Fig. 2643.—Laryngo-fissure. The thyroid cartilage is divided with a saw and a tracheotomy tube introduced.

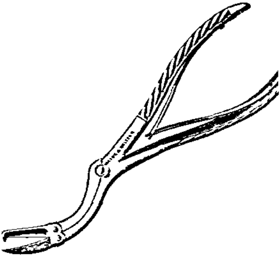

Fig. 2644.—Irwin Moore shears.

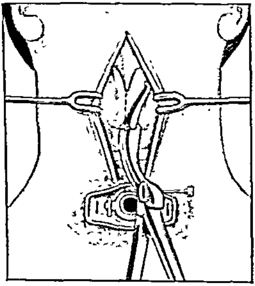

Fig. 2645.—Laryngo-fissure. The crico-thyroid membrane is incised and the division of the thyroid cartilage completed with shears.

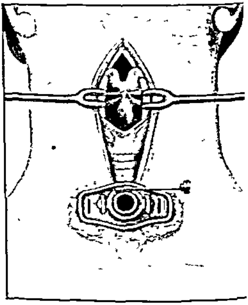

Fig. 2646.—Laryngo-fissure. The two halves of the thyroid cartilage are retracted and the interior of the larynx inspected.

so that the two halves can be retracted, which is neither possible nor desirable in men. This division of the cricoid does not cause stenosis later, as it does in children when the cricoid is cut in the operation of tracheotomy and the cut edges turn inwards.

The two halves of the larynx are then retracted with short right-angled retractors and the extent of the growth ascertained (fig. 2646). If the section has passed precisely through the middle line, a small nodule of cartilage can be seen at the anterior extremity of each vocal

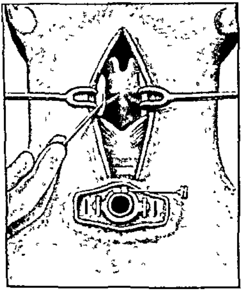

Fig 2647.—LARYNGO-FISSURE.

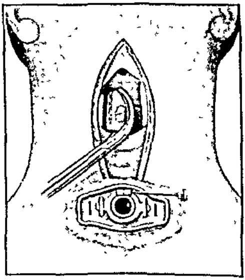

Fig. 2648.—LARYNGO-FISSURE. THE TUMOUR IS REMOVED BY CUTTING BEHIND IT WITH CURVED SCISSORS.

cord. Cough can be controlled by applying a little 5 per cent cocaine to the interior of the larynx. This helps also to define the outline of the tumour.

The trachea is then packed above the tracheotomy with a long strip of ribbon gauze, which gives complete protection against blood running down towards the lungs. If two pieces are used the upper can be changed if it becomes soaked during the operation, and the lower piece left until the end of the operation.

The growth is then removed by peeling the perichondrium off the inside of the thyroid cartilage back to the arytenoid, upwards to the edge of the thyroid cartilage and downwards to the attachment of the crico-thyroid membrane (fig. 2647). If this does not give sufficient margin below the tumour, this method of operating is unsuitable and no attempt should be made to peel the mucosa off the crico-thyroid membrane or the inner surface of the cricoid cartilage.

Two cuts are then made straight backwards, the upper above the

cord through the ventricular band, and the lower as low as possible below the cord back to the middle line. With a suitable pair of curved scissors pressed back against the posterior laryngeal wall, the remaining attachment is divided behind the growth with a single cut (see fig. 2648). This cut should pass through the vocal process of the arytenoid cartilage. The removed mass should show a clear margin of sound tissue especially behind and below the tumour, but the requisite margin varies according to the nature of the tumour (see page 4858).

An internal branch of the superior laryngeal artery, divided by this cut, just external to the face of the arytenoid, is liable to bleed at this stage. The bleeding can easily be stopped by underrunning the point with a catgut ligature on a Reverdin needle. There is no need to resort to prolonged pressure and packing.

The neck is then flexed to make sure that there are no superficial veins which bleed when the tension on the tissues outside the larynx is relaxed. The packing is removed from the trachea, and the wound closed in two layers as far down as the tracheotomy tube, the fascia and muscles with catgut, and the skin with fine silkworm-gut.

The tracheotomy tube can be removed at the end of the operation, but it is preferable to retain it in position for four or five hours, until the patient has recovered from the anæsthetic and there is no fear of recurrent hæmorrhage.

Variations in Technique. Some surgeons dispense with the tracheotomy, and operate either under local anæsthesia or under intra-tracheal anæsthesia maintained by administering the anæsthetic through a catheter which lies at the back of the larynx between the arytenoid cartilages. The return current is considered sufficient protection against the inhalation of blood downwards towards the lungs. This method allows the whole length of the incision to be sutured so that primary union of the entire wound can be obtained. On the other hand, tracheotomy enables the operator to make quite certain that no blood runs down, it diminishes the risk of surgical emphysema which can spread down to the wrists if the wound is sutured, and if any recurrent hæmorrhage occurs it is more easily arrested if the tracheotomy tube is in place or can be easily replaced. In consequence, the additional safety gained by employing the tracheotomy outweighs the risk associated with the brilliant results which can be obtained without it.

For the following reasons St. Clair Thomson advised that the greater part of the thyroid ala should be excised on the side where the tumour is situated: (1) To obtain free access to the field of operation and facilitate complete excision of the disease; (2) To allow more

satisfactory hæmostasis; (3) To promote quicker healing of the endolaryngeal wound; (4) To secure a more satisfactory airway; and (5) To avoid necrosis of cartilage.

It is true that a good airway is maintained in this way and that the perichondrial surface heals more quickly than the cartilaginous, which becomes covered with granulations slowly. It is, however, not necessary in cases suitable for laryngo-fissure, and it has the serious disadvantages of removing the cartilaginous barrier in case of recurrence, and also of making the operation of laryngectomy much more difficult should it subsequently be needed for recurrence. It is preferable therefore not to remove the cartilage in cases amenable to simple laryngo-fissure, while in cases in which a more extensive operation, short of total laryngectomy, is indicated owing to the extent of the growth across the anterior commissure or in the sub-glottic area, the technique of Hautant, in which a wider anterior and sub-glottic exposure is obtained by resection of cartilage, is more suitable.

Some surgeons use diathermy for the excision, but it is very doubtful if anything is gained by using diathermy in the neighbourhood of cartilage, in which it is likely to cause necrosis.

Preliminary ligature of the superior laryngeal artery has been suggested in order to reduce or control the hæmorrhage inside the larynx which follows the excision.

The superior laryngeal artery is generally a branch of the superior thyroid, but it may come directly from the external carotid, or it may be double. One vessel then comes from the superior thyroid and both enter the larynx together. The ligature should therefore be performed where the vessel or vessels perforate the thyro-hyoid membrane. Ohngren records that he has done this in five cases and obtained satisfactory healing without any bleeding in the larynx during the operation.

The patient should be nursed sitting up in bed, and neither morphia nor heroin should be given as both these drugs dull the cough reflex. Bromide and aspirin provide a sufficient sedative effect. If the tracheotomy tube has not been removed at the end of the operation, it can be withdrawn about six to eight hours later. The patient may be given sterilised water to swallow from a feeding cup the same evening, and before any nourishment is given he must be tested carefully in this way to ascertain that liquid does not go into the larynx when the effort is made to swallow. Some patients with a tracheotomy tube or opening can prevent food and drink going the wrong way by covering the end of the tube with a finger during the act of swallowing.

There need be no restriction on the use of the voice after the

operation. The earlier the patient begins to use the voice in moderation the more likely is a firm cicatricial band to form replacing the excised cord, and to this the sound cord can approximate and produce an almost normal voice. The side from which the cord is removed always remains fixed, and in the early days the voice is always weak because there is a waste of air passing through the enlarged glottis until the adventitious cord is formed. In a few cases this band of scar tissue does not form, so that the sound vocal cord continues to face a concavity and the patient is left permanently with a weak though useful voice which is little more than a whisper. If the voice is over-used or strained, hypertrophy of the remainder of the ventricular band may arouse the suspicion of recurrence.

From the third to the eighth week after the operation a granulation sometimes appears on the raw surface inside the larynx, most often on the edge of the cartilage anteriorly. This granulation may also give rise to the suspicion that the disease has reappeared rapidly, but its colour and character usually suggest that it is only soft granulation tissue. If left alone it becomes organised into smooth scar tissue and disappears, a process which takes several months or even a year. If it interferes much with the recovery of the voice, or if there is any real doubt about its innocent character, it is better to remove it with forceps.

The results obtained by laryngo-fissure before the end of the nineteenth century were discouraging, but at the present time a series of well-selected cases should show at least 80 per cent of permanently good results. St. Clair Thomson claims 70 per cent, and Chevalier Jackson 79 per cent of cases free from recurrence after periods ranging from 3 to 21 years. In a series of 70 cases St. Clair Thomson had 3 operative deaths, one of which was due to post-operative rupture of the œsophagus from vomiting.

Local recurrence usually appears within a year after the operation, and this may be taken to indicate either some technical error or that the case was unsuitable for the operation. When recurrence takes place at a later date it is usually in cases of sub-glottic cancer, which should not be submitted to laryngo-fissure. Thus in the 70 cases recorded by St. Clair Thomson there were 11 local recurrences, of which 8 occurred during the first year after the operation. In the remaining 3 the recurrence did not appear until after 3 years, and these cases were all sub-glottic. In one case under my personal treatment the operation was done for an endothelioma, which recurred after an interval of 8 years.

Recurrence in the cervical glands is quite uncommon after laryngo-

fissure for early cases of carcinoma, but it happens in a few cases, and there may even be a recurrence in the mediastinal glands.

Metastatic deposits are also rare, but occur occasionally in the lungs and liver. In some cases a fresh attack of the disease has occurred after several years in remote organs such as the prostate, stomach or rectum.

ANTERIOR HEMILARYNGECTOMY

When the tumour occupies the commissure and the anterior part of both vocal cords, the operation of laryngo-fissure can be varied by removing the front of the thyroid cartilage and, if necessary, the front

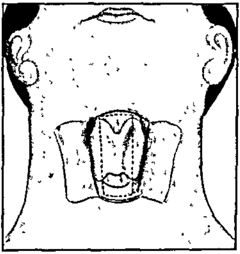

Fig. 2649.—Anterior hemilaryngectomy. (After Tapia.)

of the cricoid cartilage. According to Tapia, the operation can succeed even if the crico-thyroid membrane is attacked by the growth.

The details of the operation must be modified to suit the needs of each particular case. Tapia gives the following general description of the technique under local anæsthesia :

An incision is made from the hyoid bone to the jugulum with two horizontal incisions, one at the lower border of the hyoid bone and the other at the lower border of the cricoid. Two rectangular flaps are then raised. The pre-laryngeal segments of the sub-hyoid muscles are then resected and the anterior part of the thyroid cartilage, the cricoid and the trachea exposed. A vertical saw-cut in each wing of the thyroid cartilage is made at a distance of 2 cms. from the middle line, and, if necessary, carried downwards to include the cricoid cartilage (fig. 2649). Seizing the angle of the thyroid cartilage with vulsella the front of the larynx with the underlying tumour is then cut away from above with a knife, following the line of the saw-cuts laterally. The two skin flaps are then turned inwards and attached to the cut edges of the larynx.

After healing is complete, the front of the larynx is reconstructed from two layers of skin flaps.

In four cases in which this type of operation has been undertaken personally, the first stages of the operation have been the same as in laryngo-fissure. The sub-hyoid muscles have been retracted, for if the muscles are invaded this limited operation is not likely to succeed, although a total laryngectomy may succeed even in these circumstances. The thyroid cartilage was then sawn through as already described. If required, a sub-perichondrial dissection can be carried back from the lateral saw-cuts on either side with a blunt instrument, so that the extent of the excision is not altogether limited by the exact position of the cuts, and care is necessary that the excision inside the larynx goes wide of the growth behind.

By performing the excision from above downwards, a view of the growth displaying its exact extent can be obtained before it is excised.

At the end of the operation the wound has been closed in the same way as after laryngo-fissure and a good airway has always been obtained. It is doubtful if the plastic operation employed by Tapia is of any value in preserving the capacity of the glottis. Unless the skin flaps used in plastic operations upon the larynx are of exactly the right size and are kept taut, they are apt to fall inwards and so to diminish rather than increase the lumen of the larynx. It is generally better, therefore, to avoid plastic operations with this end in view, unless there is not sufficient skin to close the external wound, in which case a plastic operation is unavoidable.

Hemilaryngectomy by the method of Hautant is not strictly a hemilaryngectomy in the anatomical sense as was the operation performed by Gluck followed by a plastic reconstruction of the larynx with skin flaps; but although the posterior portion of the thyroid ala and the whole of the cricoid plate are preserved, the title of hemilaryngectomy is justified by the extent of tissue which is removed from the interior of the larynx.

The steps of the operation are as follows: After exposing the front of the larynx the thyroid ala on the sound side is divided vertically about a quarter of an inch from the middle line by cutting out a gutter with forceps, the inner layer of perichondrium being kept intact (fig. 2650). On the side where the tumour is situated, the thyroid ala is divided in a similar way at the junction of its middle and posterior thirds (fig. 2651). Always preserving the inner layer of perichondrium, the cricoid ring is then resected on the side of the tumour from the middle line to its junction with the cricoid plate (fig. 2652). At this

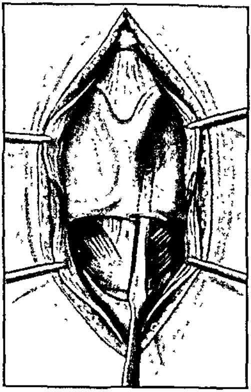

Fig. 2650.—HEMILARYNGECTOMY. METHOD OF HAUTANT. (*After Ombrédanne.*)

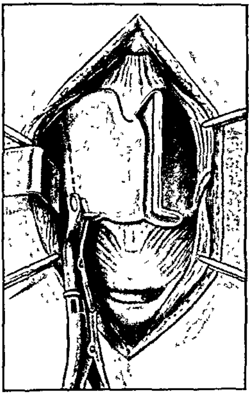

Fig. 2651.—HEMILARYNGECTOMY. METHOD OF HAUTANT (*After Ombrédanne.*)

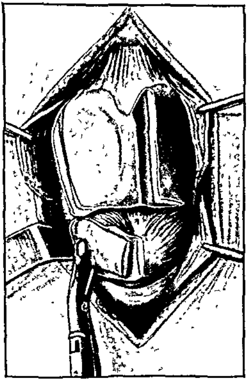

Fig 2652.—HEMILARYNGECTOMY. METHOD OF HAUTANT. (*After Ombrédanne.*)

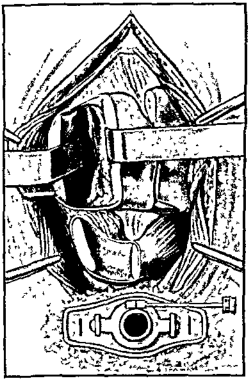

Fig. 2653.—HEMILARYNGECTOMY. METHOD OF HAUTANT. (*After Ombrédanne.*)

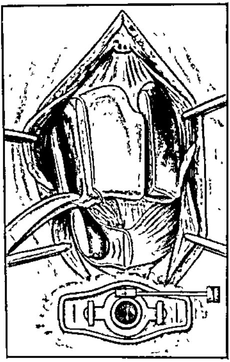

Fig 2654.—HEMILARYNGECTOMY. METHOD OF HAUTANT. (*After Ombrédanne.*)

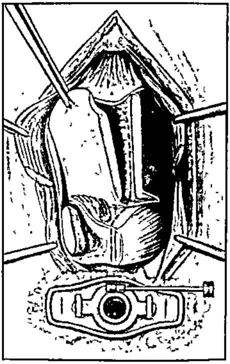

Fig 2655.—HEMILARYNGECTOMY. METHOD OF HAUTANT. (*After Ombrédanne.*)

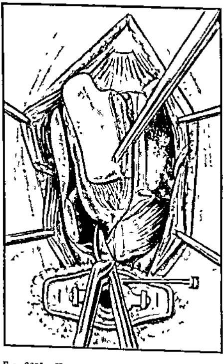

Fig. 2656.—HEMILARYNGECTOMY. METHOD OF HAUTANT. (*After Ombrédanne.*)

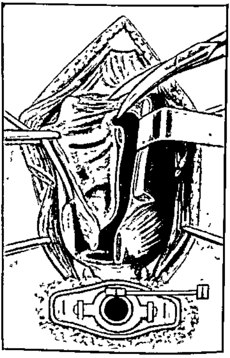

Fig. 2657.—HEMILARYNGECTOMY. METHOD OF HAUTANT. (*After Ombrédanne.*)

stage a high tracheotomy is performed. Then the cut ala of the thyroid cartilage on the side of the tumour is drawn over to the sound side, and with a blunt dissector the soft parts are detached backwards from the cricoid plate as far as or even beyond the middle line behind (see fig. 2653). In the upper part it is necessary to avoid opening the mucous membrane lining the sinus pyriformis, but the line of cleavage is easily recognised. To complete this detachment the crico-thyroid and the crico-arytenoideus lateralis muscles, which form a barrier between the upper and lower parts of the dissection, have to be divided (fig. 2654). The front of the arytenoid cartilage is cut across with curved scissors. A branch of the superior laryngeal artery usually bleeds freely at this moment. The upper edge of the thyroid cartilage is then freed from the middle line as far back as the point where it has been divided. So far the operation has been entirely extra-laryngeal and no blood or secretions can enter the airway. In the final stage of the operation the *tumour with its surrounding tissue and overlying cartilage is removed* by cutting vertically into the larynx a quarter of an inch from the middle line on the sound side following the line of section of the thyroid cartilage. The lower part of this incision at the level of the cricoid is in the middle line (fig. 2655). The incision then passes horizontally outwards and backwards above the first ring of the trachea (fig. 2656). Posteriorly the incision passes vertically from below upwards, either *in the middle line* or slightly to the sound side, and *horizontally above* so as to include the ventricular band (fig. 2657).

After all bleeding has been arrested, the cavity is packed and the wound sutured. The packing keeps the larynx from contamination by the pharyngeal secretions and enables the patient to swallow without any escape of liquid into the larynx or trachea. The packing is left in place until the fourth day after the operation and the cannula for three weeks. In men it has always been possible to dispense with the cannula, but in women the airway is no longer adequate and the cannula has to be retained permanently.

In the cases in which I have followed this technique this complicated treatment after the operation has not proved necessary; the wound has been sutured, and the patient treated in the same way as described under Laryngo-fissure, with satisfactory results.

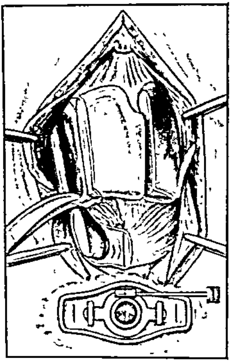

Fig 2654.—Hemilaryngectomy Method of Hautant (After Ombrédanne.)

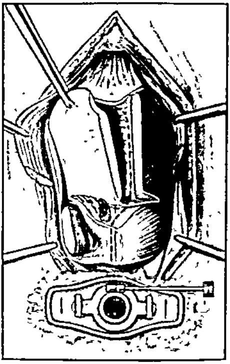

Fig 2655.—Hemilaryngectomy. Method of Hautant. (After Ombrédanne.)

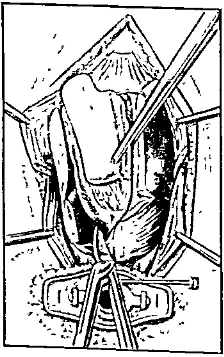

Fig. 2656.—Hemilaryngectomy. Method of Hautant. (After Ombrédanne.)

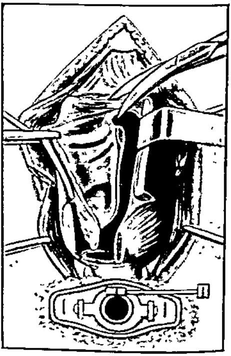

Fig. 2657.—Hemilaryngectomy. Method of Hautant. (After Ombrédanne.)

stage a high tracheotomy is performed. Then the cut ala of the thyroid cartilage on the side of the tumour is drawn over to the sound side, and with a blunt dissector the soft parts are detached backwards from the cricoid plate as far as or even beyond the middle line behind (see fig. 2653). In the upper part it is necessary to avoid opening the mucous membrane lining the sinus pyriformis, but the line of cleavage is easily recognised. To complete this detachment the crico-thyroid and the *crico-arytenoideus lateralis muscles, which form a barrier between the* upper and lower parts of the dissection, have to be divided (fig. 2654). The front of the arytenoid cartilage is cut across with curved scissors. A branch of the superior laryngeal artery usually bleeds freely at this moment. The upper edge of the thyroid cartilage is then freed from the middle line as far back as the point where it has been divided. So far the operation has been entirely extra-laryngeal and no blood or secretions can enter the airway. In the final stage of the operation the tumour with its surrounding tissue and overlying cartilage is removed by cutting vertically into the larynx a quarter of an inch from the middle line on the sound side following the line of section of the thyroid cartilage. The lower part of this incision at the level of the cricoid is in the middle line (fig. 2655). The incision then passes horizontally outwards *and backwards above the first ring of the trachea (fig. 2656).* Posteriorly the incision passes vertically from below upwards, either *in the middle line or slightly to the sound side, and horizontally above* so as to include the ventricular band (fig. 2657).

After all bleeding has been arrested, the cavity is packed and the wound sutured. The packing keeps the larynx from contamination by the pharyngeal secretions and enables the patient to swallow without any escape of liquid into the larynx or trachea. The packing is left in place until the fourth day after the operation and the cannula for three weeks. In men it has always been possible to dispense with the cannula, but in women the airway is no longer adequate and the cannula has to be retained permanently.

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CHAPTER V

Total Laryngectomy

A general survey is naturally of importance, for many of the patients are of an age at which physical disabilities and chronic diseases are common, but careful consideration is necessary before such conditions need be regarded as contra-indications. Thus a patient with a gross aortic reflux from syphilis was submitted to laryngectomy, and primary union of the whole wound without leakage from the pharynx was obtained. In another patient, who suffered from chronic bronchitis dating from an empyema eighteen years before, laryngectomy caused no aggravation of the bronchitis. In a third patient with cirrhosis of the liver in addition to laryngeal obstruction, the larynx and enlarged lymphatic glands on both sides of the neck were removed with perfect healing. This patient returned to his bibulous ways after the operation and died a year later from cirrhosis without any sign of recurrence. As a general rule, hepatic cirrhosis would be a contra-indication, but it is necessary to take all the circumstances, both physical and psychological, of each case into consideration.

Diabetic patients need preliminary regulation of diet and metabolism (see Vol. I, page 790).

Enlargement of the cervical glands is not a contra-indication, except where they are so fixed that it would be necessary to ligature the common carotid in order to extirpate the mass. Evidence of metastatic deposits would be an absolute contra-indication, but this is rare.

The principal local condition which needs attention is the mouth and teeth, and here there must be neither relaxation nor compromise. It is rare for patients who need this operation to have sound teeth with healthy gums, though this is occasionally so even at a comparatively advanced age. One lady now aged eighty had at the age of sixty-eight, when the operation was performed, a perfect set of teeth with sound gums, but in the interval she has lost all the teeth from pyorrhœa and shrinking of the gums. If her teeth had been extracted a few years before, the event showed that it would not have been a very serious loss. Most of the patients are either edentulous or have gross infection

of the gums and sockets, and so are not asked to make any great sacrifice.

In laryngectomy and pharyngotomy, however carefully the wound may be sutured, it is not always possible to prevent mucus and saliva from the mouth from coming in contact with raw surfaces. If this happens a slough is produced, and if the saliva is heavily infected the effect may be very serious. Severe local inflammation, with deep sloughing and possibly secondary hæmorrhage, results with general febrile reaction, leading sometimes to septicæmia or broncho-pneumonia from an overwhelming streptococcal infection.

Cases in which the teeth are removed and ten to twenty days are allowed to elapse for the healing of the gums and the establishment of

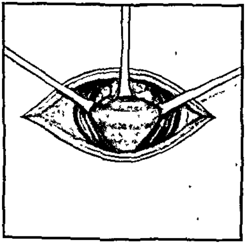


Fig. 2658.—Transverse tracheotomy.

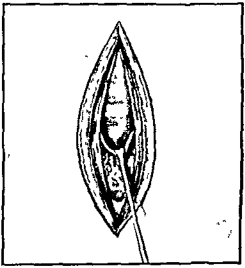


Fig 2659.—Tracheotomy above thyroid isthmus.

immunity are those in which the quickest healing with least wound infection is obtained. If the patient has long been edentulous the level of local immunity seems to fall, so that there is then sometimes some local sloughing in spite of the edentulous state, but there are not usually any serious general effects. The operation must therefore not be undertaken without removing every infected tooth, and preferably all the teeth if any need removing at all, and it is equally important to allow a sufficient period to elapse for healing. Ten days is the minimum for this, otherwise the advantage of the extraction is lost, and in the same way scaling and cleansing shortly before the operation only stir latent infection into activity and do more harm than good.

If there is more than the slightest laryngeal obstruction when the patient presents himself, a preliminary tracheotomy is essential in

order to allow the respiration to become readjusted, otherwise the laryngectomy is liable to be followed by bronchitis quite apart from any other technical error. If the obstruction is but slight, the teeth can be extracted under local anæsthesia and the patient kept at rest until the time for the laryngectomy arrives. If there is stridor and sleep is disturbed, a preliminary tracheotomy allows the extraction to be performed under general anæsthesia or evipan.

It is more convenient to do the preliminary tracheotomy through a transverse incision just above the jugulum than through the usual vertical incision, in order to leave the field above as clear as possible for the major operation (see figs. 2658–2661). A preliminary

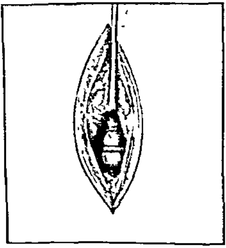


Fig. 2660.—Tracheotomy below thyroid isthmus.

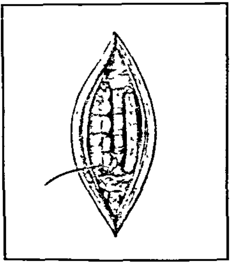


Fig. 2661.—Median tracheotomy through thyroid isthmus.

tracheotomy is to be avoided if possible, because it causes wound infection and prevents a clean operation later, while the cannula with the surrounding reaction obscures the anatomical field.

A preliminary tracheotomy therefore should not be done with the object of facilitating the operation, but only to render a patient who has reached the stage of stridor or dyspnœa from laryngeal obstruction safe for laryngectomy.

The operation is most commonly performed under local or regional anæsthesia. The nerves concerned are the anterior branches of the second to the fourth cervical nerves, from which spring the great auricular with the transverse and descending cervical plexus and also the superior laryngeal nerve. The recurrent laryngeal nerve is not concerned.

Anæsthesia is obtained by the method of Braun. Soerensen recommends that it should be carried out in the following way: A line is taken from the mastoid process to the sterno-clavicular joint and, at the junction of the upper and middle thirds, the posterior border of the sterno-mastoid is pushed forward with the tip of the left forefinger, so as to identify the underlying transverse process of the fourth cervical vertebra. The external jugular vein crosses obliquely just below this spot. The needle of the syringe is then pushed straight inwards through the skin for 1½ cms. across the transverse process in the sagittal direction. The needle is then turned vertically to avoid entering the intervertebral foramen and injury to the vertebral artery. Twenty to thirty cc. of ½ per cent novocaine are injected on each side. This is less than recommended by Braun, but the quantity is sufficient to block the whole of the cervical plexus, and if too much is used the *sympathetic, phrenic and vagus also may be blocked. No adrenalin is* required. Before the injection is made it is necessary to make certain that no blood escapes from the needle, as very serious accidents have resulted from injecting the vertebral artery and also from pushing the needle through the intervertebral foramen and the dura mater into the spinal canal.

The superior laryngeal nerve is blocked by inserting the needle straight through the skin at the upper border of the thyroid cartilage, 2 cms. from the middle line. The point of the needle is then carried upwards and outwards for 1–1½ cms. so as to traverse the muscles close to the spot where the nerve runs downwards on the thyro-hyoid membrane *on the inner side of the vessels. Having made certain that no* blood from the superior laryngeal artery or vein is escaping into the needle, 5 cc. of ½ per cent novocaine solution are injected.

Anæsthesia of the mucous membrane of the pharynx is obtained by applying cocaine solution or 2 per cent pantocain.

In England, in spite of the advantages claimed for local anæsthesia, most surgeons still prefer general anæsthesia. The patients are almost always of a type that tolerate chloroform very well, and if this is combined with infiltration of the skin along the lines of the incision with 2 per cent novocaine the amount of chloroform required is quite small.

This method inflicts much less strain upon the patient and, provided that the chloroform is skilfully administered, it does not appear to have any influence upon the operative mortality. The infiltration of the skin should be done at least a quarter of an hour beforehand in order to obtain the full effect.

The patient should be placed in the supine position with a flat

pillow or sand-bag under the shoulders, as recommended for laryngo-fissure.

The original incision employed by Langenbeck extended from the body of the hyoid bone to the jugulum in the middle line. If two transverse incisions are added at either extremity, a good exposure of the field is obtained by turning aside the two rectangular flaps of skin thus defined (fig. 2662). This incision, however, fails to comply altogether with the requirements demanded by the two factors, which, since the day of Langenbeck, have proved to be most important in establishing the operation as a reasonably safe procedure. Gluck

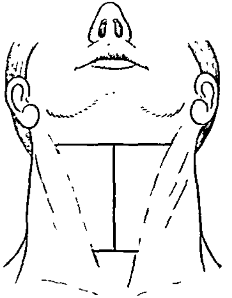


Fig 2662.—LARYNGECTOMY.
(*After Gluck and Soerensen.*)

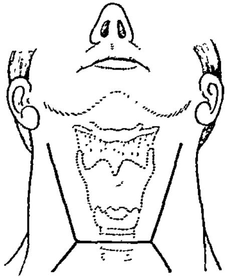


Fig 2663.—LARYNGECTOMY.
(*After Gluck and Soerensen.*)

showed that the best protection against the inhalation of blood and secretion was to close the pharynx completely and shut it off from all communication with the air-passages. If the longitudinal incision is used it lies in part directly over the line of sutures in the pharynx, and if infection causes the wound to break down and open, a fistula into the pharynx may result. The other factor is the fixation of the end of the trachea to the skin, and the provision of lateral drainage away from the orifice. Any leakage through the median incision is towards and in the neighbourhood of the tracheal orifice, and although lateral drainage is possible the form of the wound does not lend itself very readily to this object. Both these objects are more easily attained by using a single large flap of skin with its base in the neighbourhood of the hyoid bone, as first suggested by Durante (fig. 2663). This flap is

well nourished and completely covers the line of sutures in the pharynx, its lower edge can be sutured accurately to the cut edge of the trachea, and by leaving the sides of the flap partially unsutured free lateral drainage can be provided away from the trachea.

If laryngo-fissure has been performed previously through a median incision it is generally wise to excise the scar, so that it is necessary to employ the median incision already made. If also a portion or segment of the pharynx has to be excised with the larynx, so that primary closure of the pharynx is not possible and its edges must be sutured to the skin, then the median incision must be used, as a pharyngostome is being created deliberately. In simple laryngectomy for growths not invading the pharynx, which can be closed by suture, the single flap described has great advantages whenever it can be employed. Gluck and Soerensen describe the excision of the larynx in one stage from above downwards in five steps:

(1) Isolation of the larynx and ligature of blood-vessels which supply it.
(2) Excision of the lymphatic glands.
(3) Separation of the larynx from the pharynx and œsophagus, and closure of the pharynx.
(4) Separation of the larynx from the trachea, and suture of the trachea to the skin.
(5) Closure and drainage of the wound.

A transverse incision is made an inch above the jugulum from one sterno-mastoid to the other. The subcutaneous veins are defined with a blunt dissector and divided between ligatures. The anterior jugular vein will be found near the edge of the sterno-mastoid. The incision is then deepened through the fascia to expose the pre-laryngeal muscles. Incisions are next made on either side along the anterior border of each sterno-mastoid from the tubercle of the great cornu of the hyoid bone to the extremity of the transverse incision. These incisions are then continued outwards and downwards for a short distance towards the clavicle. These prolongations provide a bed in which the lowest drainage-tubes can lie comfortably later. The U-shaped flap of skin thus marked out is then turned upwards as far as the hyoid bone. The dissection is made in the layer between the fascia and the pre-laryngeal muscles, taking care to avoid buttonholing any of the vessels in the flap and so to preserve its nutrition. The external jugular should be defined in each side as the lateral incisions are made, and divided between ligatures; otherwise the lower end is apt to retract under the edge of the skin and, if overlooked, may bleed later. The sterno-hyoid,

sterno-thyroid, thyro-hyoid and upper belly of the omo-hyoid are then divided and removed (fig. 2664). As their attachments are divided their function is lost and it is useless to preserve them, and it sometimes happens that a carcinoma attacking the crico-thyroid membrane has already begun to infiltrate the muscles. In this case it is imperative to resect the muscles widely. In one such case of invasion of the muscles the patient has survived without recurrence for fifteen years.

The sterno-hyoid and sterno-thyroid are raised off the thyroid gland on a director and divided at the lower part of the wound. Above, the sterno-hyoid and thyro-hyoid are raised just below the hyoid bone

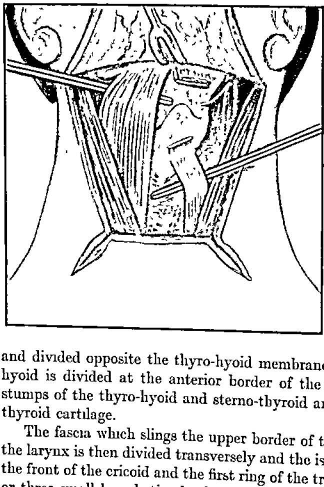


Fig. 2664.—Laryngectomy. (*After Gluck and Soerensen.*)

and divided opposite the thyro-hyoid membrane; laterally, the omo-hyoid is divided at the anterior border of the sterno-mastoid. The stumps of the thyro-hyoid and sterno-thyroid are left attached to the thyroid cartilage.

The fascia which slings the upper border of the thyroid isthmus to the larynx is then divided transversely and the isthmus separated from the front of the cricoid and the first ring of the trachea. There are two or three small lymphatic glands situated under cover of the isthmus, and these must be left attached to the larynx and not brought forward with the isthmus. If not removed with the larynx, these glands may be the cause of a recurrence later, apparently in the edge of the trachea. It is not necessary to split the isthmus unless the tumour extends far

down below the glottis, so that several rings of the trachea must be removed. If there is any obstruction to the breathing at or before this stage, a laryngotomy tube can be introduced through the crico-thyroid membrane and the anæsthetic continued through it. All bleeding points in the neighbourhood of the thyroid gland should be underrun with fine catgut on needles and tied.

The superior thyroid artery running to the upper pole of the thyroid gland is then defined, and by drawing the lateral lobe and the larynx apart the crico-thyroid artery is exposed and divided as it enters the crico-thyroid membrane (fig. 2665). The lateral lobe is then quite

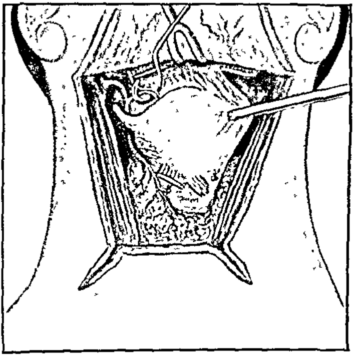


Fig. 2665.—LARYNGECTOMY
(*After Gluck and Sœrensen.*)

free from the larynx, so that they can be drawn apart with retractors and the larynx tilted over to expose the posterior border of the thyroid cartilage. The inferior constrictor and stylo-pharyngeus muscles are then divided at their attachments to the whole length of the posterior border of the thyroid ala. By making an incision along the posterior border of the thyroid cartilage, the mucous membrane of the fossa pyriformis can be dissected off from outside with a blunt instrument, but care is necessary not to perforate into the pharynx. The thyro-hyoid ligament is then divided at the tip of the superior cornu of the thyroid ala, which allows the larynx to be drawn away from the hyoid bone with a wide exposure of the thyro-hyoid membrane. The superior laryngeal artery with its accompanying veins and nerve is then easily

defined in the thyro-hyoid membrane, and the pedicle ligatured and divided (fig. 2666). It is recommended by Gluck and Soerensen that the nerve should not be included in the ligature in order to avoid reflex shock, but under general anæsthesia I have always included the nerve in the ligature without producing any alarming symptoms, and this seems the best prevention against an ascending neuritis.

(2) In many cases of intrinsic cancer of such extent that laryngectomy is required, the lymphatic glands in the neck are infiltrated with cancer cells, even if they cannot be felt by careful palpation clinically. The glands of Poirier lying in front of the larynx under cover of the edge

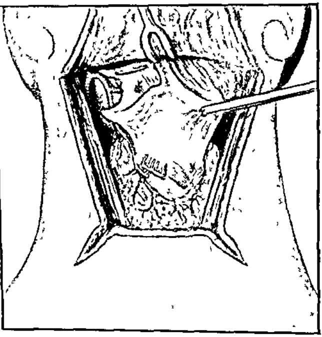


Fig. 2666.—Laryngectomy. (*After Gluck and Soerensen.*)

of the thyroid isthmus have already been mentioned. Still more important are the deep cervical glands lying on the outer side of the internal jugular vein about the level of the carotid bifurcation. By drawing the sterno-mastoid back with a retractor and opening the carotid sheath, the presence of enlarged glands can be detected. Often a few glands no larger than beans can be found, and if this is so the whole length of the vein should be searched and the glands dissected off (fig. 2667). Sometimes the only gland to be affected is one lying in the angle formed by the junction of the common facial vein with the internal jugular. In such cases this excision is sufficient to keep the patient free from recurrence for many years, and is not a serious extension of the operation. If the glandular invasion is more extensive than this, as happens

constantly in cancer of the epiglottis and pharynx, and occasionally in intrinsic cancer, the jugular vein must be resected and the whole side of the neck cleared. In such cases it is better to begin the operation with a block dissection of the internal jugular and sterno-mastoid glands under aseptic conditions, and then to follow with the laryngectomy or pharyngotomy as the situation and extent of the primary tumour demand. The skin incisions must be planned with these requirements in view. If the mass of glands is so adherent that it cannot be removed without ligature of the common carotid, the operation should not be attempted.

(3) The next step is to free the larynx from the pharynx and œsophagus. The wound should be packed well with gauze on each side

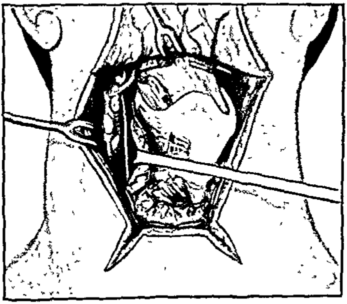


Fig 2667 —LARYNGECTOMY.
(*After Gluck and Soerensen*)

to minimise the possibility of infection from the pharynx, which has now to be opened. Although there are conditions under which the epiglottis can be safely left, it is so frequently infiltrated at its base that it is better to remove it always with the larynx. A direct incision through the thyro-hyoid membrane would cut the epiglottis off near its base, leaving it attached to the base of the tongue.

To remove it entire with the larynx, the larynx is seized with vulsella and drawn upwards with a retractor to put the thyro-hyoid membrane on the stretch. The thyro-hyoid ligament is then snipped through in the middle line with scissors beneath the body of the hyoid bone, and the larynx being drawn downwards and forwards the epiglottis gradually comes into view through the thin hyo-epiglottic membrane. The mucous membrane is then cut on each side of the

epiglottis above the edge of the thyroid cartilage, and the epiglottis drawn out of the wound so that the entrance to the larynx is exposed. In this way no blood enters the larynx, and the view enables the operator to estimate how far the tumour lies below the entrance to the larynx.

If necessary to maintain the airway, a cannula is passed between the cords, and the pharynx packed to prevent blood and saliva from running over the wound.

A transverse incision is then made through the mucous membrane below the arytenoids down to the cricoid cartilage, placing the incision

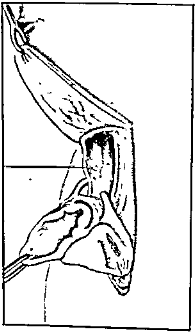
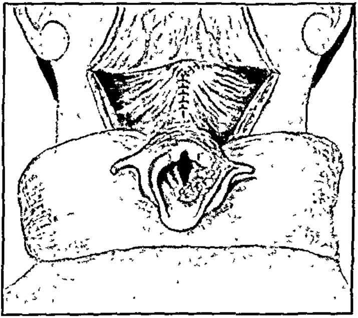


Fig. 2668.—LARYNGECTOMY. (*After Gluck and Soerensen.*)

so as to give a margin of at least ½-inch from the visible margin of the growth (fig 2668). Taking care not to buttonhole it, the mucous membrane is then dissected out of each fossa pyriformis; this has already been done partially during the first stage of freeing the larynx. The mucous membrane is dissected off the back of the larynx by snipping with scissors as far down as the lower border of the cricoid plate. At this level branches of the inferior laryngeal branch of the inferior thyroid artery are cut and must be secured. If part of the trachea has to be removed, the dissection must be carried further down between the œsophagus and trachea, but it is not usually necessary to go below this level which enables the first ring of the trachea to be removed with the larynx.

The packing in the pharynx is now removed and a No. 12 Jacques catheter passed through the mouth into the upper end of the œsophagus. The opening in the pharynx is then sutured with interrupted stitches of catgut. The sutures are inserted in a vertical row as high as possible and are placed so as to invert the edges of the pharynx. The row is then continued on each side to attach the pharynx to the base of the tongue (fig. 2669). The suture line is thus in the shape of Y with a long stem. The sutures between the base of the tongue and the pharynx are easily inserted with a Reverdin needle, but care should be taken not to perforate the pharynx with the needles. It is doubtful if anything is gained by inserting more than one row of sutures, but the

Fig. 2669.—LARYNGECTOMY. (*After Gluck and Soerensen.*)



pharynx can be made watertight, which is important at this stage, even if it leaks temporarily later.

(4) The next step is to amputate *the larynx from the trachea and to attach the tracheal opening to the skin.*

Precaution must be taken that the cut end of the trachea does not sink into the depths of the wound. The first step is to pass short sutures of fishing-gut on curved needles through the lower edges of the transverse incision in the skin above the jugulum. The front of the trachea is then divided at the required level between two rings above the isthmus of the thyroid gland. The sutures are then passed round the upper ring so that the trachea is anchored firmly to the skin in front with two sutures on either side of the median line (see fig. 2670). If these stitches are not tied too tightly the ring does not necrose, and a ring

fixed in this way keeps the tracheal opening patent, so that the patient need not necessarily wear a cannula permanently. If the cartilage necroses and prevents primary union between the trachea and the skin, a scar forms which is liable to cause contraction of the orifice unless it is kept permanently dilated.

When the front of the trachea has thus been anchored to the skin, the posterior wall can be divided safely. When this is done two small vessels always bleed near the middle line on either side. These must be secured immediately and tied, to prevent blood from running into the trachea. The skin flap is then brought down and sutured accurately

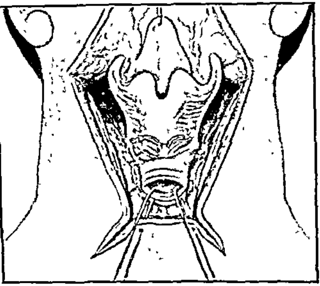


Fig. 2670 —LARYNGECTOMY. (*After Gluck and Soerensen.*)

to the sides and posterior wall of the trachea so that the orifice is surrounded by a complete collar of skin.

(5) The sides of the wound are then partially closed and three long drainage-tubes fixed each side in order to drain the large space under the flap away from the tracheal opening (fig. 2671). The lowest of these on either side lies more comfortably if the lateral incisions are prolonged downwards for a short distance as already mentioned. If a median incision with transverse incisions at either end has been used, forming two rectangular flaps, drainage-tubes must be inserted at each corner of the transverse incisions, and it is wise to drain the space under the skin flap on either side by a stab wound near the anterior border of the sterno-mastoid. If this incision has to be employed it is scarcely possible to make the collar of skin encircling the trachea so perfect as by using the single flap.

A suitable cannula must be left in the trachea and the whole wound

covered with a gauze dressing. The cannula of Moure, a modification of Lombard's tube, is convenient as it has two shields, so that the outer shield prevents dressings from slipping over the orifice. Behind the

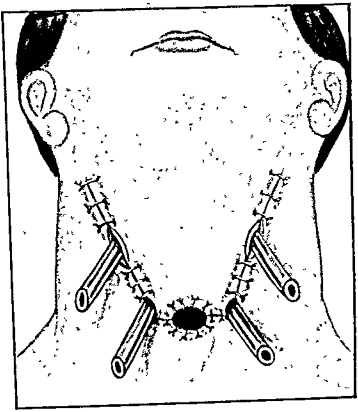


Fig. 2071 —LARYNGECTOMY. (*After Gluck and Soerensen.*)

inner shield the tube is conical, and when covered with gauze this fits the tracheal orifice closely. An inner tube passes through the whole length of the cannula from the outer shield to the inner extremity. Two of

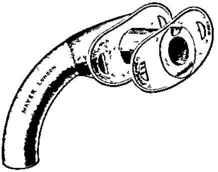


Fig. 2072.—MOURE'S MODIFICATION OF LOMBARD'S TUBE.

these tubes should be provided so that the tube can be changed quickly at each dressing.

If a preliminary low tracheotomy has been performed there need be very little modification in the operation. The transverse incision in the skin is made above the tracheotomy and the cannula is left in place.

The cannula anchors the trachea and prevents it from slipping down when divided. but the presence of the tracheotomy makes a satisfactory union of the skin with the anterior part of the trachea difficult, and it is sometimes better to leave this part of the wound to heal by granulation. The posterior wall of the trachea and the skin flap must be accurately sutured. The end of the trachea can then be packed lightly and the tracheotomy tube withdrawn a few days later when union has begun It is then replaced by a Moure cannula as described.

If a high tracheotomy has been performed the best plan is to use the median incision in the skin, but to divert it so as to surround the orifice holding the cannula (fig. 2673). The upper end of the trachea

Fig 2673.—Epithelioma with perichondritis following irradiation. Tracheotomy and fistulous openings in skin No recurrence five years after laryngectomy, which included excision of the tracheotomy track.

(*Museum, St. George's Hospital.*)

with the stoma is then excised in one piece together with the larynx (fig. 2674). This is much the safest method as the growth often extends down close to the tracheotomy, and sometimes it is even found that the tracheotomy has been made through the lower edge of the growth.

If a preliminary tracheotomy has to be performed it should be a low one, and made through a transverse skin incision above the jugulum after splitting the thyroid isthmus. This interferes least with the steps of the laryngectomy and is almost certain to be well below the tumour.

Instead of the operation of removing the larynx from above downwards, as described, some surgeons prefer to divide the trachea after

isolating the front and sides of the larynx and then to remove it from above upwards. It is claimed for this method, which was described by Perier, that the trachea being opened at a relatively early stage it is easier to maintain the airway, but the advantage of the security from blood and secretion entering the air-passages is lost. In addition, the exact relation of the tumour to the entrance of the larynx cannot be seen and exactly defined. MacKenty modified it in the following way: Using a T-shaped incision the larynx is exposed under local anæsthesia and the thyroid isthmus divided. The trachea is then cut across, a closely fitting tracheal extension tube is inserted, and the operation

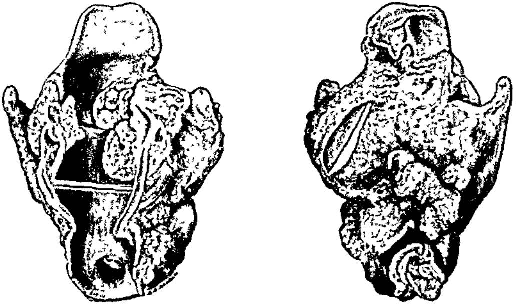


Fig 2674.—Epithelioma with massive infiltration of epiglottis and cartilages forming the right lateral wall of the larynx. The laryngectomy included the track of an urgent high tracheotomy for dyspnœa.

(Museum, St George's Hospital.)

is continued under general anæsthesia administered through this tube. The larynx is next separated from below upwards without opening the pharynx, and then allowed to fall back into its original position. The pharynx is then opened through the thyro-hyoid membrane and the larynx removed from above downwards. The results obtained by MacKenty justified this method of operating, but it does not present any apparent advantage over the operation of Gluck.

In the operation of Gluck:

(1) The trachea is not divided until the end of the operation so that blood cannot enter the air-passage.

(2) A good view of the upper aperture of the larynx and the extent of the growth is obtained before removal of the larynx is begun.

(3) The dissection of the larynx and, if necessary, of the trachea from the œsophagus can be stopped at precisely the required level at the lower edge of the cricoid or lower, so that there is no unnecessary isolation of the end of the trachea, with risk of damaging its nutrition and causing necrosis.

However carefully the wound has been protected and the pharynx sutured there is always the prospect that leakage from the pharynx may cause wound infection. With the hope of avoiding complications, broncho-pneumonia and mediastinitis in particular, operations in two or more stages, including preliminary tracheotomy, have been devised. Crile advocated an operation in two stages to guard against these complications. The trachea and larynx were exposed and the neck packed with iodoform gauze to produce a barrier of protective granulation tissue before the laryngectomy, and, in addition, preliminary tracheotomy was performed. More recently Gordon New has described an operation in several stages.

First, by a median incision, the hyoid bone is divided and the larynx and upper trachea are isolated anteriorly and laterally. At the next stage, a tracheotomy is performed or part of the cricoid is removed. Four days after this, the larynx is removed from below upwards. In forty-two cases there were only three deaths, but this complicated technique presents no apparent advantage and the selection of cases must be restricted.

The patient should sit up in bed as soon as possible. In this position respiration is hampered least, cough is most effective in expelling secretion, and the best protection against respiratory infection is afforded. Two nurses are required so that the patient is never left alone during the first week. The surgeon who attends to the dressing of the wound himself twice a day will obtain the best results, as the dressings must be arranged so that no secretions enter the trachea and drainage of the wound is kept free. A suction apparatus, not too powerful, is useful for removing the mucus which can be coughed up to the orifice of the trachea but not properly expelled. Gentle suction will remove this with less disturbance than attempts to catch it on pieces of gauze, especially when the cannula is removed to be changed at each dressing.

The cannula is provided with an inner tube which can be changed and cleaned frequently. If the pharynx leaks, which is frequent but far from invariable as some surgeons believe, the wound becomes infected, there is free discharge from the drainage-tubes and some sloughing follows. The dressing in the neighbourhood round the

drainage-tubes therefore needs frequent changing, which can be done without disturbing the cannula and its separate dressing. The tapes should be attached to the posterior shield of the cannula. The sloughs separate from the tenth to the fourteenth day, and after that the wound soon heals and the patient can swallow without leakage. Syringing or irrigating the wound serves no useful purpose and is liable to make the patient cough. When no leakage occurs from the pharynx, the patient can with safety be allowed to swallow on the tenth day and sometimes even sooner. If the stitches fixing the drainage-tubes cut out, the tubes can be kept in position by transfixing them with safety-pins through which a tape is passed and tied not too tightly round the neck. During the dressing the patient should sit up in bed, or on the edge of the bed with the shoulders leaning forward so that nothing runs into the trachea.

The usual practice is to feed the patient with a long rubber tube passed through the wider side of the nose down the œsophagus. A catheter passed through the mouth and left in place for twenty-four hours serves equally well. At the end of that time it is withdrawn and passed for each feed. This is nearly always well tolerated and the catheter is not liable to be coughed out. It also saves the patient from the discomfort of a foreign body in the nose and pharynx. In a few patients in whom the pharynx is very irritable the passage of the tube through the throat is not tolerated and the nasal feeding tube is required.

The food must be given in liquid form. During the day the patient receives two main feeds, each consisting of fifteen ounces of chicken soup or beef tea, to which is added two ounces of green vegetable purée, two ounces of potato purée and a beaten egg. This is followed by four ounces of fruit juice (plum, grape-fruit, grape or currant) with two ounces of cream. Orange juice does not mix well with cream. Water follows this. In the morning the patient receives a pint of coffee and milk in equal parts, and in the afternoon a pint of tea with milk and sugar. In the evening a pint of Benger's food made with milk and added cream is given, and during the night a pint of orange juice and water. The patient should receive at least a quart of water in every twenty-four hours. Even so the patients usually lose several pounds in weight before they are able to eat again in the ordinary way, but overfeeding causes indigestion and defeats its own object. Brandy or whisky is necessary for some patients, and if laxatives are required liquid extract of cascara or magnesium sulphate in water can be given through the tube.

The complications most to be feared are broncho-pneumonia, wound infection leading to septicæmia, and secondary hæmorrhage from sloughing. The best protection against these complications lies in careful preparation of the patient, complete arrest of hæmorrhage from the smallest bleeding point, complete closure of the pharynx, proper drainage of the wound, and vigilance in protection of the trachea during and after the operation. Although it is impossible to exclude the risk of pneumonia, usually septic broncho-pneumonia, this is much less common now owing to the precautions taken against inhalation of blood and discharges. Leakage from the pharynx, with wound infection and sloughing in consequence, is common, but an overwhelming streptococcal septicæmia is rare if the teeth have received proper attention. Mediastinitis is rare, and inevitably fatal. The operation of Crile was devised to prevent it, but free drainage and careful suturing seem to be far more effective. In one patient, who had been treated previously by X-rays, suppuration in the right sterno-clavicular joint ensued. The prominent symptom was pain at the point of the shoulder on moving the arm. This suppurative arthritis disorganised the joint, but the patient recovered after resection of the inner end of the clavicle, the side of the manubrium, and part of the first rib with its cartilage.

Deep sloughing may be the cause of secondary hæmorrhage which is difficult to control, and the chance of this occurrence is lessened if main trunks are not tied but only their small branches as far from the main trunk as possible. Sloughing may also cause the wound to open so that a fistula into the pharynx persists. This pharyngostome is less likely to result if a single large skin flap is used than if two lateral flaps with a median incision are used, but no form of skin flap is an absolute protection against it. Previous irradiation which damages nutrition and the power of repair is a factor predisposing to the formation of a pharyngostome in some cases, and is always a cause for anxiety in the management of the wound. It is necessary, in order to close a pharyngostome, to provide an inner and an outer layer of tissue covered by epithelium. The inner layer, facing inwards, may be composed either of mucous membrane or of skin, or of a combination of the two. The outer layer, facing outwards, must consist of skin. There is thus a double layer with the two raw surfaces in contact between the epithelial layers. If this principle is strictly observed the closure usually presents no very serious difficulty. It is necessary to wait until all infection has subsided and the edges of the opening have healed. A feeding tube should be introduced and kept in position. The inner layer of mucous

membrane is then dissected up and sutured over the tube with the edges inverted. Catgut stitches which do not perforate should be used. The raw surface is then covered with a skin flap, taking care that its blood supply is intact, that it can be stitched in place without tension, and that the deep and superficial lines of sutures are not superimposed. No raw surface should be left exposed. It is very rarely necessary to bring skin flaps from a distance by a tube pedicle graft, though it is occasionally necessary after irradiation in order to obtain undamaged skin.

Irritation of the vagus or of the cut ends of the superior laryngeal nerves sometimes causes reflex effects and rapid pulse. Persistent hiccough is also occasionally caused by irritation of the phrenic. In cases of tachycardia after the operation the administration of digitalis and ammonium bromide appears to have good effect.

Severe bleeding from the stomach and intestine after operating on the pharynx and larynx was described by von Eiselsberg, and is mentioned also by Gluck and Soerensen. This happened twice in patients in the series upon which this description is based, once after a lateral pharyngotomy and once after laryngo-fissure. There was no hæmatemesis, but the melæna was so severe that blood-transfusion was necessary, and the first patient, a man aged seventy-eight, would certainly have succumbed without this treatment. He made good recovery and remains well without recurrence for more than a year.

A complication which can be very troublesome is tracheitis sicca from the formation of crusts of dried secretion in the trachea. The formation of these crusts can be so abundant that the trachea becomes obstructed and it is necessary to remove them by the help of forceps and gentle suction. Even the use of a bronchoscope may be necessary. This condition usually does not last long and is best treated by oily applications to the trachea.

There is no direct evidence that these patients are especially liable to pulmonary disorders later, though Moure noted that out of 13 patients who remained free from recurrence 4 succumbed ultimately to broncho-pneumonia. It is generally found that the patients are remarkably free from coryza, due probably to the abolition of nasal respiration, which also causes degeneration of the olfactory epithelium. Heindl found that this had occurred in every one of 6 patients who died at periods of 9 to 17 months after total laryngectomy. Ullmann found that the sense of smell was lost in 50 cases tested.

SPEECH AFTER LARYNGECTOMY

All patients deprived of the laryngeal voice at once endeavour to replace it by gestures and clapping their hands to call attention. They also endeavour to speak, but articulation without the vowel sounds produced by phonation is scarcely intelligible, so that this kind of whispered speech is not of much value.

A proportion of patients, however, learn to phonate in a way which enables them to articulate in a loud and distinct though rather croaking voice. They produce a few syllables consecutively, then close the mouth, and make a movement of swallowing and proceed again, but with practice speech becomes smoother and continuous. Burger has made an elaborate study of the manner in which this voice is produced upon a patient who was cured of a basal-celled carcinoma by laryngectomy. The speech of this patient was not monotonous, he was able to sing, to speak on the telephone, to whisper, and to gargle, and he retained the senses of smell and taste. The cardia opened during speech and the positive expiratory pressure in the lungs expelled air from the œsophagus through a pseudo-glottis which formed at the mouth of the œsophagus. In this patient the stomach as well as the œsophagus took part in the function of forming an air chamber, and he was able to speak more easily after dinner because the bubble of air in the stomach is then larger. In order to force the air upwards the abdominal as well as the thoracic muscles must then be brought into action. In order to produce speech in this way the two essentials are the production of a pseudo-glottis and the formation of an air chamber in the œsophagus, or in the stomach and œsophagus.

In one case observed personally, the pseudo-glottis was formed by two bands running antero-posteriorly about the level of the middle constrictors; these were probably formed by the upper edge of this muscle. In another patient a good voice is produced but not without effort even after years of practice, and he speaks more easily sitting than standing, whilst another talks quite naturally without any more effort than a normal person.

The assistance of a voice trainer is of value in encouraging a patient to speak in this way, but there is little actual instruction that can be given. The head must be moved in every direction in order to find in what position the voice is most easily produced, and Woods recommended the administration of citric acid followed by bicarbonate of soda to provide a supply of carbon dioxide which could be expelled to produce a voice, until the patient acquired the trick of swallowing air for the purpose.

A determined and prolonged effort is required on the part of the patient in order to train himself in this way, and it is usually the younger patients or those in early middle age who succeed in acquiring this accomplishment. The normal association of respiration with speech may after a long period become dissociated, in the same way that a patient without a larynx can swallow a long drink without the necessity of stopping to draw breath.

Patients who cannot learn to speak in this way nearly always learn to use an artificial larynx effectively. It was formerly difficult to per-

Fig. 2675.—Showing artificial larynx in use. (*By kind permission of Western Electric Co.*)

suade many patients to use these instruments, which are activated by the normal current of expired air, because they were apt to work intermittently and with uncertainty, and even so produced an unnatural reedy monotonous voice, which required some effort to produce. Many such instruments were invented and the most practical was designed by Gluck.

The Western Electric Company, after much experiment and research, have now improved this model so much that the artificial voice can be produced with no more than the normal effort, and the instrument is no longer an ingenious toy but affords a practical and

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simple means of surmounting the chief disadvantage of the operation. Full instructions for use and care are supplied with the instrument, which can either be strapped over the tracheal opening by means of a pad or attached to a cannula worn in the trachea. The latter method is generally preferable. The description supplied by the Western Electric Company is as follows:

The No. 2A Artificial Larynx is designed for use by men. The No. 2B Artificial Larynx has a higher pitch than the No. 2A and is particularly designed for women. This instrument consists essentially of a flexible non-corrosive metal reed which is placed in juxtaposition to a rubber member inside a brass sound box, a mouth-piece which fits in the metal stem at the top of the sound box, and a flexible connection which is strapped over the trachea opening.

When this apparatus is being used for speaking, the air is inhaled through the hole in the side of the sound box and passes through the metal tube in the bottom of the sound box, down through the rubber connecting tube, and through the trachea connection into the respiratory organs. The air when exhaled tends to pass out the way it entered, but if the hole in the side of the sound box is closed by finger or thumb, it is forced out around the reed. This causes the reed to vibrate and to produce the sound, which passes out through the stem in the top of the sound box and the rubber mouth-piece into the mouth to be converted into speech.

In cases where the user wears a tracheotomy tube or tracheotomy cannula, it will be necessary to have a short silver tube made, one end to fit inside the tracheotomy tube or tracheotomy cannula, or the present inner tube of the cannula should be extended so as to fit inside the ferrule in the end of the rubber tube connected to the Artificial Larynx. This condition will eliminate the rubber pad and trachea connection. The user can have such a piece made by a silver-metal worker The end of the tubing which fits into the ferrule should have an outside diameter of half an inch.

A beautifully finished model designed on similar principles is also made for the Mayo Clinic by the Central Scientific Company of Chicago.

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CHAPTER VI

Pathology and Surgery of Cancer of the Laryngo-Pharynx and the Hypo-Pharynx

Tumours included in these groups arise on the epiglottis and ary-epiglottic folds, for which the name epilaryngeal tumours (Trotter) is appropriate, on the lateral wall of the pharynx opposite the arytenoid with spread towards the aperture of the larynx, and in the hypo-pharynx, in the fossa pyriformis and in the lowest part of the pharynx behind the cricoid. There are also a few cases, mostly women, in which the tumour arises on the posterior wall of the pharynx opposite the epiglottis.

The great majority of these tumours are squamous-celled epitheliomata of various grading, but on the epiglottis basal-celled carcinoma is sometimes encountered, and on the aryepiglottic fold papillary carcinoma may be found. It is this group of epilaryngeal tumours and tumours of the fossa pyriformis which are generally described as extrinsic carcinomata of the larynx.

The ætiology has already been discussed and contrasted with that of the intrinsic tumours.

In all the situations mentioned the first symptom is usually merely a vague discomfort, difficulty in clearing the throat, and slowly increasing dysphagia. Deglutition is more affected than phonation. In some patients pain in the ear may be the only symptom for weeks or even months, and in many there may be no local symptoms at all in the earlier stages. Attention is first attracted by an enlarged gland in the neck, and even on examination the site of the primary tumour may be difficult to discover.

Epithelioma of the epiglottis in its early stage is relatively benign, especially if it starts on the edge at a distance from both the tongue and the larynx. This is the only occasion when biopsy is justifiable in order to confirm the diagnosis in a tumour of the pharynx, and it can be done without danger of dissemination. It then has but little tendency to lymphatic extension to the cervical glands, and removal by pharyngotomy gives a good prospect of permanent cure. Unfortunately

the symptoms produced at this stage are slight, so that it is not often that the opportunity for early treatment occurs. More frequently cases are seen when the tumour has extended downwards towards or into the larynx, or laterally along one or other of the aryepiglottic folds. In the latter the tumour may be removed by lateral pharyngotomy after a dissection of the cervical glands, but if the tumour has descended on the laryngeal surface of the epiglottis into its base and into the laryngeal aperture a total laryngectomy is required.

It not infrequently happens also that the lingual surface of the epiglottis is the site of an epithelioma, but this is usually by the extension of a tumour originating in the vallecula. In this case there is generally a deep ulcer immediately in front of the epiglottis, and the tumour has reached the stage of spreading to the muscular structure of the tongue. Trotter has recommended that such tumours, if seen at an early stage, should be excised by splitting the lip, the mandible and the tongue in the middle line and removing the body of the hyoid bone. As soon as the neighbourhood of the tumour is approached the incision is diverted to either side to enclose it. To be suitable for treatment by such means the tumour must still be in the early stage, and localised to the mucous membrane without infiltration of the muscles of the tongue, so that the field for this operation is restricted. The operation also has the disadvantage that the complication of division of the mandible is introduced, but it is comparatively bloodless and keeps the glandular field quite separate from the wound in the pharynx.

A carcinoma arising on the aryepiglottic fold may take the characteristic form of an ulcer with a raised everted edge, but it may also appear as a large tumour with a tendency to be pedunculated. In this case the effect of muffling the voice is a pronounced feature and there may be choking attacks. Although the tumour may appear formidable at first sight, closer examination may show that the arytenoid cartilage is still moving, proving that there is little infiltration at the base of the pedicle and that such a tumour offers a favourable opportunity for removal by lateral pharyngotomy. The lymphatic drainage from this region is free, and therefore invasion of the cervical glands must be assumed in every case.

A common site of origin of epithelioma in this region is on the lateral wall of the pharynx at the level of the arytenoid cartilage. If the tumour overhangs the entrance to the larynx at all it may be difficult to distinguish from one which arises on the aryepiglottic fold, but it is possible to do so by asking the patient to phonate forcibly which will show that the fold is clear and that the arytenoid cartilage moves

freely. The distinction is important because such a tumour can be removed by pharyngotomy, with sufficient sacrifice of the lateral wall of the pharynx without encroaching upon the larynx, though extension to the aryepiglottic fold takes place as the growth advances.

The most formidable of the tumours which arise in this region is the epithelioma which originates without symptoms in the fossa pyriformis, and is often first indicated by a mass of glands in the neck. Growing in this recess under cover of the thyroid ala the tumour soon attacks and infiltrates the lateral wall of the larynx, on its outer side invading the ala and spreading in the perichondrium, and on its inner

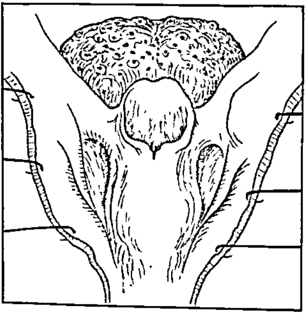

Fig. 2676.—The fossa pyriformis. (After Ducuing.)

side involving the cricoid and intrinsic laryngeal muscles so that the corresponding vocal cord becomes fixed.

The site of origin in the depths of the sinus pyriformis (fig. 2676) and the absence or trivial character of early symptoms almost invariably preclude the diagnosis of an epithelioma in this situation at an early stage. Some discomfort or difficulty in swallowing is usually the earliest symptom; next in frequency comes the discovery by the patient of an enlarged cervical gland, and less commonly changes in the voice, difficulty in breathing, cough, or pain in the ear are noticed. In a few cases salivation is the first symptom (Ducuing). In the more advanced stages muffling of the voice, stridor, dysphagia, and pain, both locally and referred to the ear, are prominent symptoms.

Examination with the mirror may show nothing abnormal in the

early stage, but later œdema of the aryepiglottic fold above the entrance to the sinus pyriformis and fixation of the corresponding vocal cord are evident. A sign which is important is a persistent accumulation of secretion at the entrance to the sinus. A further extension of the growth upwards may enable the observer to see the upper edge of the growth when the entrance to the pyriform fossa is opened by a forcible effort of phonation.

External examination of the neck frequently reveals widening of the larynx, showing that the ala of the thyroid has been attacked. There are thus four possible signs of the presence of the growth, and as a fifth its edge may be visible on careful search.

The only difficulty in diagnosis is presented by syphilis and possibly by a foreign body, but the history and appearances are usually so characteristic that no mistake should be made. Biopsy is unnecessary and unjustifiable, though it is usually undertaken as a preliminary to radiation.

The treatment of this variety of tumour is discouraging. Soerensen has stated that, although in former years a small percentage of cases submitted to laryngectomy gave a good result, the results have been so poor in recent years that he has been inclined to abandon operation on this class of case. Ducuing has stated the position as follows:

> "Deaths during the operation, post-operative pneumonia, cellulitis of the neck and mediastinum, violent secondary hæmorrhage, and recurrence at a distance from the original tumour, even when it had been properly excised, were the cause of cruel and discouraging failure for surgeons of a former day. The appearance of physical methods of treatment was hailed with joy, and those who had to admit the futility of surgical interventions, of pharyngectomies or pharyngotomies whether median or lateral, high or low, foresaw the great advantages which it was reasonable to expect from using physical methods alone or in combination with surgery. X-rays, radium, and electro-coagulation thus became associated with surgical treatment. Unfortunately the perilous situation of the tumour, the lack of early diagnosis, and the almost invariable presence of lymphatic extension, always form an unfavourable combination, in the face of which we are almost as impotent as our forerunners."

This dreadful picture is only too near the truth, but it is unnecessarily gloomy, because some patients can be saved by excision of the larynx with a sufficient area of the pharynx; but the operation must

be undertaken before the growth has perforated the wall of the pharynx and reached the planes of the neck.

The operation should be planned as follows:

The incision for the laryngectomy should be in the median line with transverse incisions at either extremity, but on the side of the tumour the upper transverse incision should be prolonged outwards and upwards towards the ear, so that a large skin flap is turned back. The jugular vein is then resected and the neck cleared of glands. The great cornu of the hyoid bone is then removed to give free access to the pharynx, and the larynx is excised with a wide area of pharynx around the tumour. No attempt is made to close the pharynx completely, but the edges are stitched to the edges of the skin flaps, so that no raw surface is left uncovered and the patient is left with a pharyngostome which is closed later by a plastic operation. Two patients operated upon in this way by the writer live in comfort and are actively engaged in business after seven years.

An alternative method of treatment is to clear the neck of glands and then to treat the tumour with deep X-rays, but radiation alone or radiation after the tumour has attacked the laryngeal cartilages is useless. If more advanced growths are submitted to operation, the larynx with a complete segment of the pharynx must be removed. This operation, which was planned and practised by Gluck, and is required also for the more advanced cases of post-cricoid carcinoma, leaves the patient with the skin flaps attached to the pharynx above and to the œsophagus and trachea below.

The posterior wall of the pharynx is thus formed by the skin flaps, and the anterior wall must be reconstructed later by a plastic operation. In a few cases a palliative gastrostomy (see Vol. I, page 447) or tracheotomy is indicated at a late stage.

Carcinoma in the post-cricoid area, unlike carcinoma elsewhere in the pharynx and larynx, is much commoner in women than in men, as already mentioned (see page 4855), and in its typical manifestation occurs almost exclusively in young and middle-aged women. It is not infrequent between the ages of thirty and forty, and one patient aged twenty came under my personal observation. A patient in the care of Tilley was aged twenty-two.

There is frequently, if not invariably, a long history of difficulty in swallowing, extending over many years, so that the onset of the disease is insidious, as it appears to attack women with narrow gullets. Women who suffer from the Plummer-Vinson syndrome, which is characterised by chronic glossitis, atrophy and dryness of the mucous membrane of

the pharynx, cracks and fissures at the angles of the mouth, anæmia of secondary type, and dysphagia, sometimes develop this form of cancer. These women are often very small, and examination of the gullet shows it not only to be small and dry, but sometimes to be partially closed at its entrance by a web in the post-cricoid region. Definite symptoms are sometimes of sudden onset.

One lady had had difficulty in swallowing all her life, but she came late one evening after dinner because, as she believed, a piece of hare had stuck in her throat. Examination showed no abnormality, but a small œsophagoscope was held up by a post-cricoid carcinoma. Operation a few days later showed that the tumour had already extended into the thyroid gland and had become widely diffused in the muscular coat of the œsophagus.

The tumour usually starts as a flat plaque on the anterior wall of the pharynx opposite the plate of the cricoid. It tends to spread both upwards and downwards from this site, but more downwards, and as it does so it gradually encircles the pharynx and upper end of the œsophagus, so that it comes to resemble the cricoid cartilage in shape. This extension downwards has a tendency also to perforate the thin wall of the pharynx laterally so that the lateral lobe of the thyroid gland is invaded at its posterior edge, and this extension is constantly seen in cases which are at all advanced.

As a rule, examination with the mirror shows nothing abnormal, but, as the tumour extends upwards, the mucous membrane covering the arytenoids and cartilages of Santorini becomes purple and œdematous at the posterior margin of the larynx, and later the upper edge of the epithelioma is visible. Examination with a small œsophagoscope is of great importance, but it must be done most gently and no attempt should be made to force the beak of the instrument past the growth in order to estimate its length, as this can only cause bleeding and damage. For the same reasons and because of the danger of causing dissemination, no biopsy should be performed.

It is, however, at times difficult to distinguish a simple erosion from an early carcinoma. On two occasions in women affected with the Plummer-Vinson syndrome supposed carcinoma proved at operation to be simple erosion. The implantation of a skin flap, however, gave relief from dysphagia to each case which would otherwise have called for gastrostomy. Dysphagia is for a long time the only symptom and the tumour is freely movable on the back of the larynx, but when the base of the tumour invades the crico-arytenoideus posticus muscles double abductor paralysis of the cords supervenes, and dyspnœa becomes added to dysphagia, though there is often no change in the voice.

The growth progresses so slowly that the dysphagia is tolerated until a high degree of stenosis is produced, so that severe dysphagia always indicates that the disease has extended far down the œsophagus and is quite inoperable.

The cervical lymphatic glands which usually show enlargement are those which form the second group of deep jugular glands high under the sterno-mastoid, so that an enlargement appears high up below the ear rather than in the usual primary situation in the neck at the point where the common facial vein joins the internal jugular. In consequence of the situation of the tumour and of the free lymphatic drainage from this part of the pharynx, any attempt at radical excision must take into account the necessity for a bilateral operation on the glands. Severe dysphagia, indicating a long stricture of the lower pharynx and upper œsophagus, or anything more than moderate enlargement of the cervical glands, especially if bilateral, precludes any hope of successful operative treatment.

In a few early cases without palpable glandular enlargement, lateral pharyngotomy can give a satisfactory result. The operation must be modified by first performing tracheotomy through a transverse incision, after which a flap is cut from the front of the neck with its base over the anterior edge of the sterno-mastoid of the affected side. The neck is then cleared of glands on that side without resecting the sterno-mastoid, and the pharynx is opened above the tumour after removing the posterior edge of the thyroid ala, but not necessarily dividing the superior laryngeal nerve nor removing the great cornu of the hyoid bone. The pharynx is divided below and behind the arytenoids, and a complete segment containing the tumour is dissected off the back of the larynx and resected. The flap of skin is then turned into the wound and its upper and lower edges are stitched to the cut edges of the pharynx above and the œsophagus below, so that all raw surfaces are covered and the patient is left with a deep open gutter lined with skin behind the larynx. This gutter is transformed into a closed canal by a plastic operation a few weeks later. In more advanced cases, in which glands can be palpated but are not fixed, and where there is evidence that the larynx is invaded, either from swelling of the mucous membrane covering the arytenoid cartilages or from impaired mobility or fixation of one or both vocal cords, a total removal of the larynx with a complete segment of the pharynx is necessary after dissecting the glands on both sides of the neck. This operation should only be undertaken if the glands can be removed without resection of the internal jugular vein or of the sterno-mastoid muscle.

Unfortunately, even if the operations can be undertaken successfully without local recurrence, the patients are likely to succumb within two to four years from deposits in the mediastinal glands.

As palliative operations, gastrostomy for the relief of dysphagia, or tracheotomy for the relief of dyspnœa caused by bilateral abductor paralysis of the cord, may be required.

A great variety of technical methods have been proposed to expose the entrance to the larynx by pharyngotomy. Thus the approach may be through a transverse, a median longitudinal, or a lateral incision, or a combination of two of these, and again it may be supra-hyoid, trans-hyoid, or sub-hyoid. It is unnecessary to go into the history of these operations further than to say that at least nine different routes have been designed and put into practice. Of all these the two which have been found eventually to give satisfaction are sub-hyoid pharyngotomy and lateral pharyngotomy by the method described by Trotter.

It is necessary, however, to discuss first what may be expected from the operation of pharyngotomy and to define the objective to be attained when the operation is undertaken for the treatment of various conditions.

Whichever route is adopted, the operation consists of a first stage in which the pharynx is laid open in order to expose the tumour; a second stage in which the tumour is excised with a surrounding margin of sound tissue in accordance with its individual situation, character and extent, and a third stage in which the wound is repaired according to the requirement of the case.

Thus in the simplest example of a tumour which does not encroach upon the lateral wall of the pharynx, for instance a tumour upon the tip of the epiglottis, or a small epithelioma upon an aryepiglottic fold, the pharynx is laid open either by sub-hyoid or lateral pharyngotomy and the tumour exposed. The wound made by excising the tumour would then be quite separate from the wound made for its exposure and would be repaired quite separately.

There is a difference when the tumour lies either wholly or in part upon the lateral wall of the pharynx, because in the stage of excision part of this wall must be removed, and consequently the incision which opens the pharynx must be so placed that it can be used also as part of the incision with which the tumour is to be extirpated after it has been fully exposed. The two stages of the operation are thus not definitely separate from one another. Lateral pharyngotomy alone could fulfil the demands in this case, but there is the

further requirement that if any appreciable area of the pharynx is excised, a skin flap of sufficient area to replace it and cover any raw surface must be turned into the wound.

The difficulty in combating sepsis arising from the pharynx presents itself here in a form similar to but even more formidable than in the case of total laryngectomy. The same precautions must be taken against it, by strict attention to the mouth—if possible by making the patient edentulous and allowing ample time for the gums to heal. It is more formidable here, however, because the entrance to the larynx is left open and in communication with the pharynx, whilst in excision of the larynx, as Gluck showed, one factor of safety lies in the complete separation of the air-passage from the pharynx, and the danger of pneumonia from inhalation is diminished. For this reason it is preferable not to employ sub-hyoid pharyngotomy, but to use lateral pharyngotomy in all cases, and to stitch the edges of the pharyngeal wound to the skin in all cases, so that the pharynx lies partially open.

Trotter has shown that, in the simple form of the operation where the pharyngotomy can be closed if the wound of excision be obliterated with mattress sutures, it is technically possible to obtain healing without leakage from the pharynx, or with leakage so slight that the pharynx closes without a plastic operation.

If the pharynx is stitched to the skin in all cases, it is easy to cover all raw surfaces so that wound infection is but slight or is entirely avoided, and the free drainage of the mouth and pharynx through the opening in the neck to the exterior protects the larynx against inhalation of mucus and discharges. A plastic operation is required to close this opening when healing is complete, but the additional safety and the ease with which the enormous wound in the neck is covered and protected from infection, as well as the freedom from respiratory complications compensate for the longer convalescence.

SUB-HYOID PHARYNGOTOMY

Sub-hyoid pharyngotomy was described almost exactly a hundred years ago by Malgaigne and was recommended by Iversen as a good method of opening the pharynx, but it has had a high mortality from inhalation pneumonia. It has, however, been used with success by Gluck and Soerensen in a series of cases for small tumours of the epiglottis and aryepiglottic folds. If a general anæsthetic is used a preliminary tracheotomy is necessary, but there is no danger of aspiration of blood if local anæsthesia is employed.

An incision 4 inches long is made along the lower border of the

hyoid bone, dividing skin, fascia and platysma. Subcutaneous veins which cross the line of the incision are divided between two ligatures. The hyoid branch of the superior thyroid artery is ligatured if necessary. The hyoid branch of the lingual is not encountered as it runs along the upper border of the bone. The pre-laryngeal muscles attached to the lower border of the hyoid bone, the sterno-hyoid, thyro-hyoid and omo-hyoid, are divided close to the hyoid bone with care, because they must be sutured at the end of the operation (fig. 2677).

The space between the hyoid bone and the upper border of the thyroid cartilage is thus exposed. In the centre lies the thick, firm median thyro-hyoid ligament which extends laterally on either side into the thin thyro-hyoid membrane. Further out still it thickens into the lateral thyro-hyoid ligaments which connect the tip of the superior

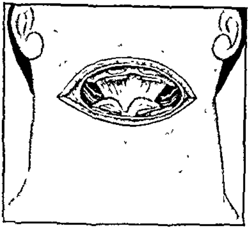

Fig. 2677.—SUB-HYOID PHARYNGOTOMY
(*After Gluck and Soerensen.*)

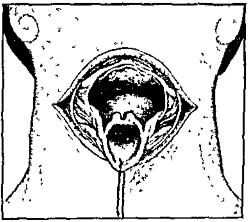

Fig. 2678.—SUB-HYOID PHARYNGOTOMY
(*After Gluck and Soerensen.*)

cornu of the thyroid cartilage to the tubercle of the great cornu of the hyoid bone. The superior laryngeal nerve and vessels perforate the thyro-hyoid membrane near its attachment to the thyroid cartilage to reach the interior of the larynx. Damage to the nerve, which causes loss of reflex closure of the glottis, can be avoided by cutting through the median thyro-hyoid ligament only. If the incision must be widened further, the thyro-hyoid membrane must be divided above close to the hyoid bone, thus avoiding the bundle of vessels and the nerve. In any case the nerve must be spared on one side at least. The level at which the thyro-hyoid ligament is divided depends upon whether the pharynx is to be opened between the tongue and the epiglottis, or whether the epiglottis is to be cut away from the larynx and left attached to the tongue.

If an incision is made transversely between the hyoid bone and the

thyroid cartilage, the incision passes through the base of the epiglottis, and the upper part is left attached to the tongue. This manœuvre would be indicated where the intention is to resect the base of the tongue along with the epiglottis for a tumour on its lingual surface. If it is intended to open the pharynx between the base of the tongue and the anterior surface of the epiglottis, the thyro-hyoid ligament must be cut away from the hyoid bone by drawing it upwards and cutting directly upwards behind it with knife or scissors. The tip of the epiglottis can then be seen through the thin hyo-epiglottic membrane, which is divided, and the tip of the epiglottis can be seized and drawn out of the wound (see fig. 2678). The tumour is excised through the exposure thus obtained. The wound is then closed in layers.

This method has the advantage that if an operation for removal of lymphatic glands is required, it is done through a separate clean wound in the neck on a subsequent occasion.

CHAPTER VII

Lateral Pharyngotomy

In lateral pharyngotomy a much wider approach to the entrance of the larynx is obtained. Just as the mandible dominates the approach to the side of the pharynx above, so the hyoid bone dominates it below, and Trotter has devised a form of lateral pharyngotomy in which free access to the side of the pharynx is obtained by removing the great cornu of the hyoid bone and the ala of the thyroid cartilage. Removal of glands is combined with the pharyngotomy and excision of the tumour.

The lines of the incision in the neck should be infiltrated with novocaine, as this diminishes the amount of chloroform required.

The first step in the operation is tracheotomy. This should be done under local anæsthesia with 2 per cent novocaine, whereby the period *of general anæsthesia is shortened and any risk of respiratory obstruction, however brief, is avoided. Respiratory obstruction is the most important factor in producing bronchitis or broncho-pneumonia because it induces aspiration of infective secretions.* The thyroid isthmus is divided, an opening to fit the tracheotomy be is cut in the front of the trachea as already described for the operation of laryngo-fissure, and a long Durham tube is inserted. Chloroform is then administered through the tracheotomy tube with perfect safety.

A curved incision is made in the fold of the neck from a point mid-way between the point of the chin and the body of the hyoid bone, backwards over the sterno-mastoid to end below the ear. From the convexity of this incision another is made along the anterior border of the sterno-mastoid almost to the sterno-clavicular joint. The skin flaps thus marked out are dissected up and held aside with Lane forceps. The deep cervical fascia is then divided along the borders of the area exposed. The sterno-mastoid is divided near its lower attachment, and the internal jugular vein is ligatured and divided. The whole mass, including fat, lymphatic glands and muscle, is then dissected off the carotid artery up to the horizontal ramus of the jaw (see fig. 2679). The mass includes the submaxillary gland, so that the facial artery must be tied and divided, both where it enters the gland and also as it turns over the mandible in front of the masseter. Some facial

veins require to be ligatured here also. The mass of tissue is then turned backwards, taking care to preserve the hypoglossal nerve, and it is usually better to isolate it by dividing the occipital artery. The upper end of the jugular vein is then exposed, separated from the internal carotid artery, and ligatured near the base of the skull (fig. 2680). The whole mass is then removed by cutting across the sterno-mastoid at its origin and removing the lower pole of the parotid gland. In this way all lymphatic glands are removed from the submental, submaxillary and deep cervical regions. The external carotid should not be tied, but the branches should be secured as far as possible from the main trunk, to minimise the risk of secondary hæmorrhage. The loss of the

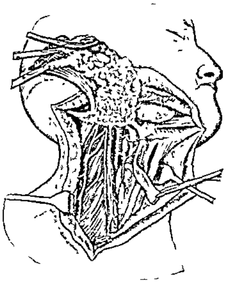

Fig 2679.—Radical operation for excision of malignant glands in neck. (*After Crile*)

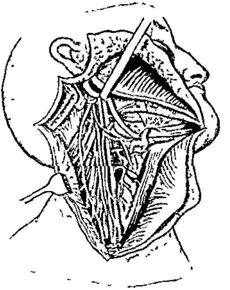

Fig 2680.—Radical operation for excision of malignant glands in neck. (*After Crile*)

sterno-mastoid causes but slight functional impairment and its absence prevents pockets forming in the wound during healing. The wound is then packed off and the pharyngotomy undertaken.

The inferior constrictor and stylo-pharyngeus are divided and detached from the thyroid cartilage, and the great cornu of the hyoid bone is freed from the hyo-glossus, middle constrictor and thyro-hyoid (fig. 2681). The sterno-hyoid may also be divided if a wider exposure is required. To complete the exposure of the hyoid bone and thyroid cartilage, the superior laryngeal nerve and vessels must be divided, and if necessary the upper pole of the thyroid gland with the superior thyroid vessels resected. The whole of the great cornu of the hyoid bone and the posterior two-thirds of the thyroid ala are then removed,

leaving the lateral wall of the pharynx exposed (fig. 2682). The tumour can then be palpated from outside, and if it should be decided that it is useless to continue the operation it can be abandoned at this stage without doing any serious harm.

The wound is again packed to keep it free from pharyngeal mucus, and the pharynx is then opened by a longitudinal incision, or, if the lateral wall is the seat of the tumour, the incision is so placed that it serves in part for the excision with a margin of at least ½-inch, as well as for the exposure of the surface of the tumour (see fig. 2683). The entrance to the larynx is protected with a strip of ribbon gauze packing

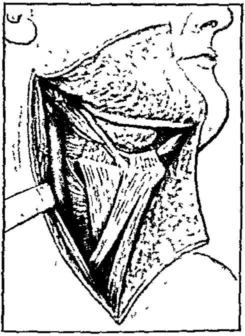

Fig. 2681.—LATERAL PHARYNGOTOMY. (*After Trotter*.)

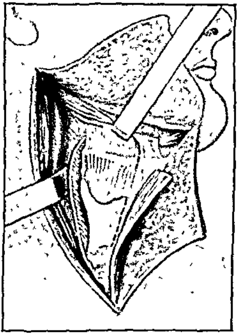

Fig. 2682.—LATERAL PHARYNGOTOMY. (*After Trotter*.)

to exclude blood, and the excision of the tumour with a margin of half or preferably three-quarters of an inch is completed. The gap left is closed by mattress sutures of catgut, and it is recommended by Trotter that the incision in the wall of the pharynx should be closed, the muscles sewn over, and the wound in the neck left widely open but filled with boracic powder.

For the reasons already mentioned it has been found much safer to close the opening in the pharynx at its lower part only, and to stitch the edges all round to the skin. To accomplish this the extremities of the skin incisions are united with fishing-gut, and the pharynx with the mucous membrane at the base of the tongue united to the central

part of the skin incision with silk stitches. If fishing-gut is used the membrane tears, and if catgut is used necrosis of the skin is caused along the stitch holes. The best union is obtained by using silk, which suits both skin and mucous membrane. In this way all raw surfaces are covered and the wound is drained by a tube passed through a stab wound above the clavicle and by another at the lower corner of the original incision in the skin.

A feeding tube is passed into the œsophagus through the opening

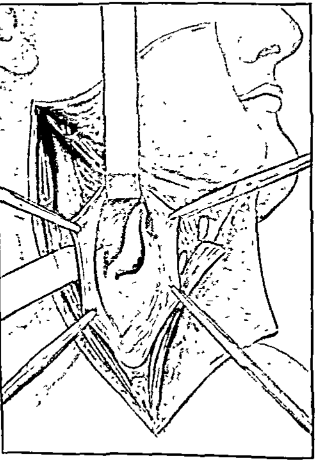

Fig. 2033.—Lateral pharyngotomy.
(*After Trotter*)

in the pharynx. The tracheotomy tube should be left in place for a week or ten days, and when it is certain that there is no laryngeal obstruction it can be removed, preferably in the morning so that the patient becomes accustomed in the daytime to its absence and the change of breathing.

The union of skin and mucous membrane is complete in about ten to fourteen days, and the pharyngeal opening then usually contracts to a slit, but this depends upon how much of the lateral wall has been

removed (fig. 2684). The pharyngostome is closed at the end of three or four weeks by the plastic method already described, skin being turned inwards to form part of the inner aspect of the pharyngeal wall if necessary.

When lateral pharyngotomy is used for the excision of a post-cricoid tumour it can be modified in several ways. The operation should be reserved for cases in which there is no fixation of either cord, in which there is only a moderate degree of dysphagia, in which the lymphatic glands are not palpable, and in which the tumour is not yet visible with the mirror behind the larynx. The diagnosis must then

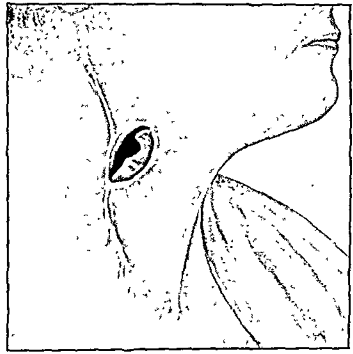

Fig 2684.—Wound healed after lateral pharyngotomy for epithelioma of aryepiglottic fold in a woman.

depend upon endoscopic examination, and the precise level, situation and extent should be determined as far as possible without damaging the growth.

The preliminary tracheotomy should be performed under local anæsthesia through a transverse incision. A flap of skin about 2 inches wide is then cut from the front of the neck with the base along the anterior border of the sterno-mastoid, the ends of the incision being prolonged for an inch upwards and downwards along this line. The neck is then cleared of glands, preferably without resecting the internal jugular vein unless it is evidently necessary, and without resecting the sterno-mastoid, which is retracted so that the dissection can be carried back underneath it, especially towards the upper end.

The part of the pharynx concerned can then be exposed by removing the posterior two-thirds of the thyroid ala and, if necessary, the upper pole of the thyroid gland, *but without resecting the great cornu of the* hyoid bone and without dividing the superior laryngeal nerve. This avoids much of the disturbance with deglutition which is usually associated with the operation, and it gives a fully sufficient exposure in cases which are suitable for this method of approach. A complete segment of the lower pharynx and upper œsophagus is removed, including a margin of at least ½-inch above and below the growth. Care must be taken that in detaching the pharynx from the back of the larynx, the crico-arytenoideus posticus muscles are not injured and that the recurrent laryngeal nerve is neither cut nor stretched. The flap of skin is

Fig 2685.—Wound healed after lateral pharyngotomy with implantation of skin flap to replace excised segment of pharynx and œsophagus. A rubber tube provides a communication between the pharynx and œsophagus and keeps the flap of skin in position against the back of the larynx. Transverse tracheotomy above jugulum.

then implanted into the defect and stitched with silk to the mucous membrane of the pharynx above and of the œsophagus below, so that an open gutter is formed in which a feeding tube can lie behind the larynx. The wound left on the front of the neck is closed with mattress stitches of silkworm-gut. The skin is here loose enough to cover the raw surface without difficulty, and the retention of the sterno-mastoid is of help in forming the gutter for the new pharynx.

At the end of a week, when healing of the edges of the wound is well advanced, a large drainage-tube is introduced so that it lies vertically behind the larynx extending from the pharynx above to the œsophagus below (fig. 2685). The pressure exerted by the tube, which is held in place by a tape, holds the skin flap in position and makes a continuous channel between pharynx and œsophagus without the

formation of a spur. The patient is fed by passing a catheter through a hole cut in the side of this rubber tube.

At the end of six to eight weeks the rubber tube can be withdrawn, and the open gutter is transformed into a complete tube of skin by a plastic operation performed over a feeding tube introduced through the nose and kept in place until the wound has healed.

To show the results which can be obtained by lateral pharyngotomy in suitable cases Trotter mentions the following:

Case 1.	Aryepiglottic fold (extensive glands)	Free from	recurrence	7	years
,, 2.	Pyriform sinus	,,	,,	20	,,
,, 3.	Lateral wall (large primary growth)	,,	,,	5	,,
,, 4.	Lateral wall (moderately early) .	,,	,,	7	,,
,, 5.	Lateral wall (large primary growth; *extensive glands*) . . .	,,	,,	7	,,
,, 6.	Lateral wall (early)	,,	,,	$3\frac{1}{2}$	,,
,, 7.	Posterior wall	,,	,,	8	,,
,, 8.	Post-cricoid (extensive) . .	,,	,,	9	,,

A statistical survey is difficult on account of the varieties in situation and character of the tumours and the variations required in the technique.

CHAPTER VIII

Pharyngo-Laryngectomy

In cases where a pharyngeal tumour has invaded the lateral wall of the larynx so that the arytenoid cartilage and vocal cord are fixed on that side, and in cases of tumours arising in the fossa pyriformis, no good result can be obtained by an effort to preserve the larynx, which must be excised with a sufficient area of pharyngeal mucous membrane on its borders, and, if necessary, with a complete segment of the pharynx.

A method of partial resection has already been mentioned. The median incision with cross incisions at either end must be used. The rectangular flap on the side corresponding to the tumour is made large so that a complete clearance of the lymphatic area can be undertaken, with resection of the jugular vein. The great cornu of the hyoid bone is then removed on the same side, and the larynx excised in the usual way from above with a sufficient margin of the pharynx round the tumour. Only the lower parts of the pharynx and the incisions in the skin are then closed if the upper part cannot be closed without tension. The edges of the pharynx are stitched to the skin with silk in the upper part, and after an interval of four to six weeks the pharyngostome is closed by a plastic operation in which skin is turned to face inwards (see page 4927).

In more advanced cases of pharyngeal cancer, some tumours of the fossa pyriformis, and in cases of post-cricoid cancer which do not conform to the limitations mentioned, the larynx and a complete segment of the pharynx must be excised (fig. 2686).

The technical difficulties of the operation have been overcome by the methods of Gluck and Soerensen, and a preliminary gastrostomy as proposed by de Quervain is not necessary.

A median incision is made from the hyoid bone to the jugulum with two incisions across it at either end. The two rectangular skin flaps thus marked out are to be used at the end of the operation to bridge the gap left between the lower end of the pharynx and the upper end of the œsophagus, and they thus form the posterior wall of the new pharynx and œsophagus which is to be constructed afterwards. The

defect must bear some relation to the size of the tumour which has to be removed, and the flaps must be cut so that they are fully long enough to cover the defect without tension when sutured above and below. In men the upper incision should, if possible, be made below the hair line as the epithelial surface will face inwards to the pharynx, but this is not often feasible and should not be allowed to influence the more important consideration of cutting the flaps long enough. The lymphatic glands must always be cleared on both sides of the neck, and the larynx is then isolated, as already described, without opening the

Fig. 2686.—Advanced post cricoid carcinoma. The epithelioma rises up behind the arytenoid cartilages and surrounds the pharynx below, and also invades the left lobe of the thyroid gland from behind. Pharyngo-laryngectomy.

pharynx. The isthmus of the thyroid gland should be divided and the lateral lobes detached from the side of the trachea.

With a blunt dissector the pharynx is then detached from the prevertebral fascia in the layer of loose retro-pharyngeal connective tissue which contains only a few small blood-vessels (see fig. 2687). This dissection is carried upwards and downwards to the extent estimated to be necessary by palpation of the tumour through the wall of the pharynx, so that a margin of at least $\frac{3}{4}$-inch can be left beyond the tumour when the pharynx and œsophagus are incised. A flat piece of folded gauze is then passed behind the pharynx across the front of the vertical column to protect the mediastinum. The rest of the wound is then packed, and the pharynx is opened as in simple laryngectomy by drawing forward the larynx with the epiglottis so that the tumour can be seen from above. The mouth is emptied of saliva and secretion by suction, and packed with a strip of gauze. The pharynx is then divided $\frac{3}{4}$-inch above the tumour (see fig. 2688). The œsophagus is next separated from the trachea, divided below the tumour, and a feeding

tube is fixed into its lumen. The trachea is divided and fixed to the skin in front, as in simple laryngectomy. The wound must then be closed so that no raw surface is left exposed, but there must be a bridge of skin placed between the openings of the trachea and the œsophagus,

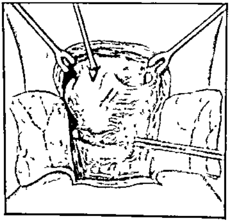

Fig 2687 —Pharyngo-laryngectomy (After Gluck and Soerensen.)

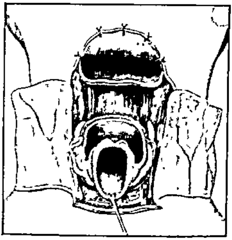

Fig 2688 —Pharyngo-laryngectomy. (After Gluck and Soerensen.)

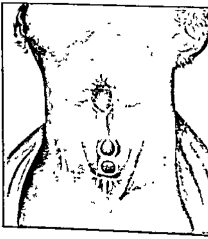

Fig 2689 —Healed wound after pharyngo-laryngectomy for post cricoid carcinoma, showing openings into pharynx and œsophagus joined by skin, and opening into trachea

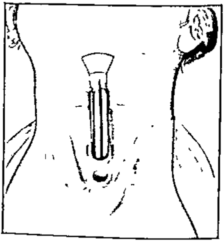

Fig 2690 —Gluck's tube in position after pharyngo-laryngectomy for post-cricoid carcinoma.

as without this the later plastic operation for reconstructing the front of the pharynx presents great difficulties. The end of the œsophagus is therefore detached from the trachea and drawn upwards. The two skin flaps are laid against the vertebral column and their lower edges sutured to the posterior wall of the trachea. The tracheal opening is

thus surrounded by a collar of skin. The œsophagus is then drawn up without tension and stitched between the edges of the median incision, *so that the trachea and œsophagus are separated by at least ½-inch, or rather more if possible.* The rest of the skin incision is sutured in the median line and the skin is stitched all round above to the pharynx and the root of the tongue. Only the corners of the original incision are left open for drainage.

If the end of the œsophagus cannot be fixed in this way, it must be left with a tube fixed in it, but if this is likely to happen the operation should not be undertaken.

As a rule, healing takes place in a fortnight with very little sloughing or suppuration, but four to six months must be allowed to elapse before the plastic operation for reconstruction of the pharynx can be undertaken, as the skin flaps must acquire a free blood supply before their bases can be divided (fig. 2689).

In the meantime feeding can be resumed by the mouth by using a soft india-rubber funnel which bridges the gap between the base of the tongue and the œsophagus (fig. 2690). The upper end of the funnel must be cut to suit each case and introduced by folding the funnel so that it can be grasped with a sponge-holder and passed up behind the tongue, where it opens out and rests quite comfortably. The lower end need not pass far down the œsophagus, and the contrivance is held in place by a tape tied round the neck. The funnel must be soft enough not to irritate the tongue and not to pass up too high, otherwise the patient will retch, but it must be strong enough not to collapse when in position. A certain amount of adjustment is therefore necessary before the patient tolerates the tube and is comfortable, but once in position it enables the patient to swallow easily and naturally and it prevents leakage of saliva almost entirely, so that the patient gains weight. It need not be changed daily; two or three times a week or even less often is sufficient.

This method is, however, a makeshift and the front of the pharynx should be reconstructed by a plastic operation whenever possible after four to six months, when the skin now forming the posterior pharyngeal wall has acquired a fresh blood supply. This is shown by its colour and by the acquisition of some mobility between the skin and the front of the vertebral column. It is necessary also to make certain that there is no tendency of the scars at the sites of the original incisions to contract.

The scar on the front of each pharyngeal opening above and below is excised so that the edge of the tongue and the edge of the œsophagus

can be dissected up anteriorly for a short distance. A rectangular flap of skin is then cut on either side with its base towards the middle line, its length corresponding to the length of the defect and its width great

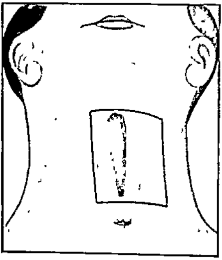

Fig 2691.—Plastic operation for closure of pharyngostome. (*After Gluck and Soerensen.*)

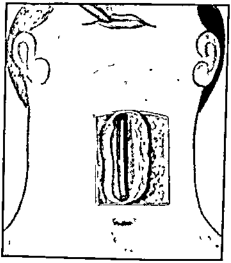

Fig 2692.—Plastic operation for closure of pharyngostome. (*After Gluck and Soerensen.*)

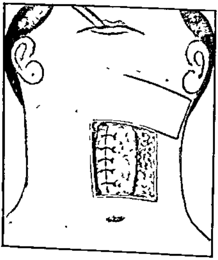

Fig 2693.—Plastic operation for closure of pharyngostome. (*After Gluck and Soerensen.*)

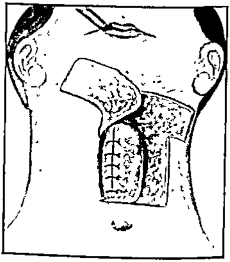

Fig 2694.—Plastic operation for closure of pharyngostome. (*After Gluck and Soerensen.*)

enough to enable it to meet its fellow when turned forwards, and so to form a tube without dissecting it up too far towards its base in the middle line (fig. 2691). These flaps, which should not be of equal width, are then stitched with fine catgut above to the base of the

tongue, below to the anterior edge of the œsophagus, and in the middle or laterally, if they are not of the same width, to one another (fig. 2692). A new pharynx lined with skin is thus formed, with a raw surface facing outwards (fig. 2693). This raw surface is covered with a flap of skin cut from the chin and the lower part of the cheek where the skin is loose and of good texture. A horizontal incision is made from the chin outwards to a point below the ear on the side from which the larger of the two skin flaps was cut. The lower edge of the covering

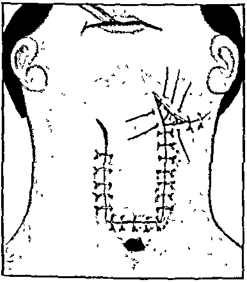

Fig. 2695.—PLASTIC OPERATION FOR CLOSURE OF PHARYNGOSTOME
(After Gluck and Soerensen)

Fig 2696.—THREE YEARS AFTER PLASTIC OPERATION TO RECONSTRUCT PHARYNX AFTER PHARYNGO-LARYNGECTOMY FOR POST CRICOID CARCINOMA.

flap is bounded medially by the edge of the opening in the pharynx, and further outwards by the upper transverse incision with which the first and larger skin flap was cut. This incision is lengthened laterally parallel to the upper one, and the two are joined by another vertical incision beneath the ear. This flap must be wide enough and long enough to cover the raw surface easily when sutured to the wound edges on the front of the neck, and must be freed sufficiently to allow it to be rotated 90 degrees into position without strangling its blood supply (fig. 2694). The defect along the lower jaw is easily closed with the

help of a few deep supporting stitches (see fig. 2695). A feeding tube should be passed through the nose before the operation is begun and the patient is fed by this for ten days until healing is completed. Occasionally a corner of the outer flap sloughs, but the fistula usually closes spontaneously without difficulty. Figure 2696 shows the neck of a woman three years after this operation for a post-cricoid carcinoma.

Gluck and Soerensen state that in 334 cases of pharyngo-laryngectomy 78 died from the effects of the operation, whilst 10 per cent of the cases gave permanently good results. The others sooner or later had a local recurrence or died of distant metastases. Many of these patients came for operation in a very unfavourable condition, so that a more drastic selection of cases would have given better results statistically, but whenever possible no case was refused operation.

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PART XXIX

TONSILS AND ADENOIDS
AND
RETRO-PHARYNGEAL ABSCESS

by

CHARLES KEOGH

TONSILS AND ADENOIDS AND RETRO-PHARYNGEAL ABSCESS

CHAPTER I

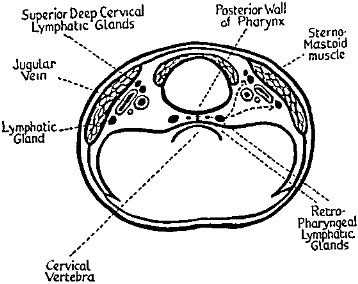
Retro-Pharyngeal Abscess

Both the *acute* and the *chronic* type may communicate with an abscess in the neck.

SURGICAL ANATOMY

Retro-pharyngeal abscess may be defined as a collection of pus lying behind the constrictor muscles of the pharynx. A glance at figures 2697, 2698, 2699 and 2700 will explain how pus in this position can produce obstruction to respiration, and can track up and down or pass laterally through the loose areolar tissue of the muscle planes. The posterior wall of the pharynx is more tightly bound down to the prevertebral fascia in the middle line (fig. 2697) and this explains why the abscess, when examined clinically through the mouth, usually lies to one or other

Fig. 2697.



side of the middle line (fig. 2698). In infancy and early childhood, the retro-pharyngeal space contains a few relatively large lymphatic glands (fig. 2697). These lie in front of the arch of the atlas. They receive lymphatics from the naso-pharynx and adenoid tissue and drain into the superior deep cervical group in front of and behind the jugular vein. Suppuration in these retro-pharyngeal glands is the commonest cause of the acute form of abscess.

The above anatomical facts explain the early age incidence of retro-pharyngeal abscess, the retro-pharyngeal glands and adenoid tissue tending to atrophy in later years. The frequent complication of secondary cervical adenitis, with possible

suppuration in the neck and formation of a communicating abscess (fig. 2699), is also easily explained. Another point of interest is that the larynx lies in a relatively higher position in the infant than it does in later childhood. Hence respiratory obstruction is most often present in the very young.

ACUTE RETRO-PHARYNGEAL ABSCESS

Ætiology and Pathology.

This form of abscess is usually found in children between the ages of six months and three years. It is rare in later childhood and adult life. The pale unhealthy child with infected adenoids, living in an overcrowded home, is the usual sufferer. It sometimes occurs in infants a few weeks old. The organisms most often responsible are the streptococcus pyogenes and the staphylococcus aureus.

Clinical Signs and Symptoms.

In the infant and younger child, obstruction to respiration and swallowing is often the first and most important indication of the presence of an abscess. The miserable infant produces in its pharynx a peculiar mewing cry, alternating with a sharp staccato quack as its unhappiness increases. Alarming signs these, which often lead the unwary to a hasty diagnosis, and the unfortunate sufferer to a diphtheria ward in a fever hospital. The hard brassy expiratory bark of laryngeal diphtheria is quite a different sound.

Enlarged cervical glands or a fluctuating cervical abscess may be present. In the early stages the mouth is wet and dribbling with saliva, but as obstruction increases the lips are sore and dry, the tongue furred, and the pharynx becomes gummed with sticky mucus. Fluid or food may be refused, or be swallowed with great difficulty. Inflamed glands in the neck immobilise the head, and misery is complete. The severity of the picture depends, of course, upon the degree of obstruction to the larynx and œsophagus, and to the pain produced by muscle movement over tense abscess walls.

A small acute retro-pharyngeal abscess, particularly when present in a child of two years or more, may cause very few symptoms.

Operation.

In the acutely obstructed infant very little in the way of an anæsthetic is necessary. Some surgeons prefer to give no anæsthetic at all. Respiratory relief can almost always be obtained by passing a small rubber anæsthetic tube or airway past the abscess so that the end is just above the larynx. The writer was Senior Casualty Officer at the ospital for Sick Children for over three years, and naturally had to deal a number of these cases. An anæsthetic was always administered. found to be a great advantage, and all the children did well.

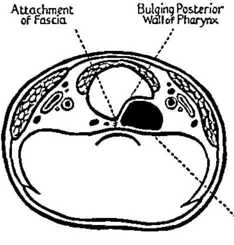


Fig. 2698.

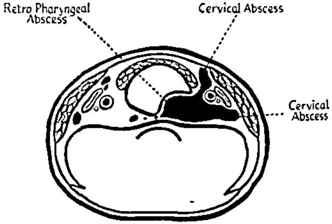


Fig 2699

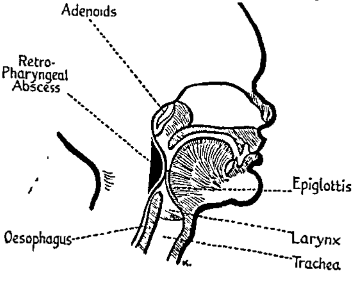


Fig. 2700.

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The child is placed on his back with the head lower than the body. A gag is placed in the mouth, the maximum point of fluctuation of the abscess incised, and the contents of the abscess sucked out with an efficient suction apparatus. The abscess may be aspirated through a hollow needle before it is opened if there is much pus. If no suction apparatus is available, a very small opening should be made in the abscess and the pus wiped away with swabs as it oozes out. There is no point in letting the pus swamp over into the throat and nasal passages as this may quite easily prolong convalescence by causing infection in the nose When all the pus has been evacuated the opening is made large enough to allow free drainage, and the child is then placed on his side. A very short anæsthetic is needed, and a little chloroform is usually all that is necessary. Oxygen is helpful throughout the operation Atropin beforehand prevents hypersecretion and makes everything easier.

If no anæsthetic is given, the small child must be wrapped tightly in a blanket and the head held gently but firmly by an assistant.

After Treatment

This aims at keeping the mouth as clean as possible. In the tiny infant this is best done by wiping out the mouth frequently with swabs soaked in saline or a solution of sodium bicarbonate The foot of the bed may be raised. In older children gargles should be given. Fluids only should be given at first, and from the second day, soft foods An enema may be given if necessary, and the normal regulation of the bowels attended to as soon as possible.

Recovery is usually rapid, but in very debilitated children with pyrexia it may be a few weeks before recovery is complete. After reasonable convalescence the adenoids, which are usually the primary source of infection, must be attended to.

CASE 1

History. Boy, aged 2 years. Three weeks: sore throat; cervical glands enlarged. Three days: great enlargement of glandular swelling left neck.

On examination. Pale ill child, marked respiratory difficulty, no cyanosis. Temperature 103 degrees; pulse 150; respiration 30. Furred tongue. Tonsils enlarged and nearly meeting in middle line, large tender mass of glands left angle of jaw. Glands palpable right side also. Soft fluctuant swelling post-pharyngeal wall to left of middle line at level of base of tongue.

Operation. Retro-pharyngeal abscess incised under light chloroform anæsthesia. Ten cc. of pus evacuated. Streptococci on culture.

Result. Temperature fell two days later and cervical adenitis rapidly subsided. Child discharged fit and well three weeks later.

CHRONIC RETRO-PHARYNGEAL ABSCESS

Ætiology and Pathology.

This usually occurs in older children from 6 to 14 years of age and

seldom gives rise to symptoms. It is usually discovered on routine examination when chronic cervical adenitis is present. The tubercle bacillus is usually responsible, but a non-virulent streptococcus is sometimes found. Skiagrams of the cervical vertebræ must always be taken. These will sometimes show evidence of caries.

In the writer's opinion chronic tuberculous retro-pharyngeal abscess often arises from a focus in the adenoid bed, and the caries may be secondary to the retro-pharyngeal abscess. It must always be remembered that a chronic retro-pharyngeal abscess may communicate with an abscess in the neck. This can easily be demonstrated clinically by palpating the neck abscess with a finger on the swelling in the throat.

Operation.

In these chronic cases the retro-pharyngeal abscess is best drained through the neck. Adequate drainage of the neck abscess will allow the swelling in the throat to be evacuated by simple pressure. Occasionally a chronic tuberculous sinus will run from the neck to the retro-pharyngeal abscess, and this must be followed up and cleaned out. Aspiration of the retro-pharyngeal abscess may be tried as a preliminary measure.

After-Treatment.

If no opening has been made in the retro-pharyngeal wall, treatment is greatly simplified and attention is devoted to the neck. This is best dressed by swabbing out the cavity with perchloride of mercury, 1 in 1000. If there is a good deal of pus present in the neck, the cavity should be kept loosely packed for a few days with gauze soaked in the same solution. It is sometimes possible to close the wound completely at the time. If caries of the cervical vertebræ is present, immobilisation of the neck and treatment on general lines for surgical tuberculosis is recommended.

CASE 2

History. Girl, aged 13 years. Two years previously, cervical adenitis right side. One year later, abscess formed. Large fluctuating swelling incised and drained. Tubercle bacilli present in pus. Received inoculation treatment.

On examination. Small sinus present on anterior border of right sterno-mastoid. Large swelling to right side of post-pharyngeal wall. X-ray examination, cervical vertebræ negative. No pain, no cough, no dyspnœa, appetite good.

Operation. Retro-pharyngeal abscess aspirated. Tubercle bacilli and non-hæmolytic streptococci present in pus. Three weeks later, sinus in neck dissected out. Track passed anterior to sterno-mastoid and behind great vessels, leading to retro-pharyngeal abscess. Abscess drained. No evidence of cervical caries. Four weeks later, discharged fit and wound healed.

CHAPTER II

Tonsils and Adenoids

ADENOIDS

SURGICAL ANATOMY IN RELATION TO OPERATION (fig. 2701)

THE adenoid tissue lies in the naso-pharynx, and is made up of longitudinal folds of lymphoid tissue covered by columnar ciliated mucous membrane. The

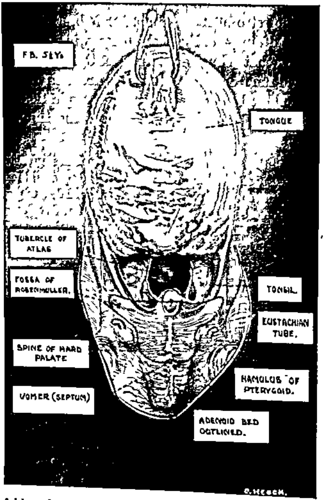

Fig. 2701.—THE SURGICAL ANATOMY OF THE TONSILS AND ADENOID BED. CHILD AGED 5½ YEARS AT OPERATION. ADENOID BED SEEN THROUGH THE PALATE, SHOWING IMPORTANT RELATIONSHIPS.

folds radiate from a point which lies just behind the base of the uvula, the larger folds passing in a forward direction towards the nose (figs. 2702 and 2703). The adenoid bed lies mainly on the basi-occipital bone. In early childhood, ossification is not complete and the surgeon must be careful not to cut into the soft

cartilage. Its lower half is separated from the bone by the superior constrictor muscle and the two heads of the longus capitis muscle (see fig. 2703c).

When the pharyngeal reflexes are present, the superior constrictor will contract on stimulation, forming a ridge just below the adenoid tissue. It can easily be torn with the curette if the surgeon does not wait until the naso-pharyngeal *sphincter is relaxed before carrying his blade through.*

The blood supply is from small prevertebral arteries, but two very large veins drain the adenoid tissue and pass under the upper border of the superior constrictor muscles and between the two heads of the longus capitis (see fig. 2703c). *These two large veins are usually responsible for* hæmorrhage from the adenoid bed. Pressure in the middle line, on the posterior pharyngeal wall opposite the base of the uvula, will control hæmorrhage. The author has demonstrated these veins in numerous dissections.

Fig. 2702.—ADENOID TISSUE REMOVED BY OPERATION. ACTUAL SIZE.

The lymph drainage is to the retro-pharyngeal lymph glands lying anterior to the body of the atlas, and thence to the superior deep cervical glands (see fig. 2697).

On either side lie the Eustachian tubes with their orifices, the adenoid tissue extending well into the fossæ of Rosenmuller under the tubes (see fig. 2703A). The *blade of the adenoid curette must pass under the tubes and must never on any* account be allowed to injure them, as even the slightest injury may produce cicatrisation and partial closure of the tubes, with impairment of hearing later.

Anteriorly lies the vomer, the base of which also forms part of the adenoid bed. To either side of the vomer are the posterior nares. When removing adenoids with a *curette, the blade first engages the adenoid tissue at the base of the vomer.* It is also just as well to remember that there may be intra-nasal extensions of the adenoid folds, and when these occur, simple removal of the adenoid tissue in the naso-pharynx will improve the airway very little, if large intra-nasal extensions are left behind.

From numerous dissections which the writer has made, it is obvious that the adenoid tissue has a capsule precisely similar to that of the tonsil. This, of course, is formed mainly of areolar and fibrous tissue which separates it from its bony and muscular bed. From this capsule trabeculi pass up into each fold.

Ætiology and Treatment.

The adenoid tissue can become hyperplastic and cause severe upper respiratory obstruction by blocking the post-nasal space. This condition occurs in early infancy and early childhood, and is usually preceded by some form of infection.

The adenoid tissue tends to shrink after puberty, but never entirely disappears even in adult life. It can always be recognised with a microscope, and almost always by the naked eye. Simple adenoid hyperplasia occasionally takes place after the age of sixty. *Obstruction* in the new-born, due to adenoid hyperplasia and resultant adhesions, can often be freed by the gentle passage of a soft catheter well lubricated

with liquid paraffin. The catheter should be passed beyond the naso-pharynx into the pharynx and moved gently to and fro. It has been my practice for several years to use this simple technique in new-born infants with nasal obstruction. The catheters are passed once

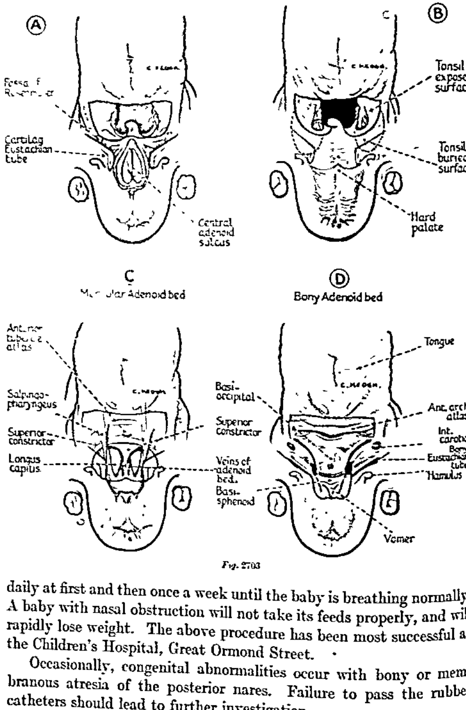

Fig. 2703

daily at first and then once a week until the baby is breathing normally. A baby with nasal obstruction will not take its feeds properly, and will rapidly lose weight. The above procedure has been most successful at the Children's Hospital, Great Ormond Street.

Occasionally, congenital abnormalities occur with bony or membranous atresia of the posterior nares. Failure to pass the rubber catheters should lead to further investigation.

ADENOIDS—INDICATIONS FOR OPERATION

(1) *Nasal Obstruction (hyperplasia ; adhesions).*

If nasal obstruction persists after an acute infection, the patient should be examined for evidence of hyperplasia of the adenoid tissue. This can usually be seen, even in the very young child, by gently raising the soft palate. A mass of adenoid tissue can easily be palpated with a finger on the soft palate. Placing a finger behind the soft palate into the post-nasal space frightens the child, and is almost certain to cause a little bleeding and produce adhesions. If the condition is untreated, alteration in the speech will be noticed. The child seems to suffer from a continuous cold, and there is occasional earache and restlessness at night. This type of child commonly suffers from nocturnal enuresis. This is easily explainable. The child happens to be sleeping on his back and the tongue sags down against the hard palate. Normally he would then automatically breathe through his nose, but if enlarged adenoids are present, there is a subconscious realisation of the terrors of suffocation. The child usually cries out in fear, and passes urine in the bed. The sleeper seldom awakes completely, but turns over, assumes a different position, and continues breathing through the mouth.

If obstruction due to adenoids persists for a few years, retarded development, alteration of facial expression, and deformity of palate and teeth will take place. In children suffering from respiratory diseases such as asthma, unresolved pneumonia, or any condition where there is poor development and expansion of the chest, it is essential to remove the adenoid tissue if the physician considers that the nasal obstruction is aggravating the condition.

(2) *Middle Ear Disease.*

The majority of cases of disease of the middle ear start with a primary infection in the adenoid bed. During the exanthemata it is common to get an infection of the adenoid bed, and this may quite easily spread up the Eustachian tubes.

It is unwise to remove adenoid tissue during the acute stage of otitis media, but all cases of chronic otitis media should have an examination of the adenoid bed. It is my practice to re-admit for adenoidectomy and tonsillectomy all children who have suffered from mastoiditis, on their return from the convalescent home. All children with otitis media which does not clear up in three or four weeks should be suspected of adhesions or of infection in the adenoid bed, and in such cases operation will hasten the cure.

A number of children complain of periodic deafness and earache without otorrhœa. If the child has enlarged adenoids which have become adherent to the Eustachian tubes, adenoidectomy will clear the condition.

(3) *Cervical Adenitis.*

The superior deep cervical group of glands receives the drainage from the adenoid bed as well as from the tonsils themselves, and repeated cervical adenitis is very suggestive of infection in the adenoid bed. It must be emphatically stated that badly infected adenoid tissue often gives no signs of obstruction, and shows no signs of hyperplasia although the tissue itself may be riddled with small abscesses.

In cases where cervical adenitis persists, the possibility of a tuberculous infection in the adenoid bed must be borne in mind. The writer has often demonstrated the presence of tubercle bacilli and granulomatous tuberculosis in adenoid tissue in cases where tubercle bacilli have also been cultured from a cervical abscess. It must be remembered that not all cases of cervical adenitis are tuberculous—indeed the majority would appear to be due to the presence of infection in the adenoid tissue or in the tonsils themselves, due to one of the various forms of cocci.

(4) *Retro-Pharyngeal Abscess.*

After the evacuation of a retro-pharyngeal abscess, when the child has returned from convalescence, it is advisable to remove the adenoid tissue. I have demonstrated small abscesses deep within the adenoid tissue in such cases. These abscesses sometimes contain tubercle bacilli. The presence of these abscesses will show the surgeon how important it is to remove the adenoid tissue complete—that is to say, through the areolar layer which separates it from the muscles and bone.

(5) *Sinus Infection.*

I am convinced that many forms of sinus infection in childhood are secondary to stasis of secretions in the nose, due to obstruction by adenoid tissue in the naso-pharynx. At the Princess Elizabeth Hospital for Children all cases with infected sinuses are examined by X-rays, and the adenoids removed. The condition of the sinuses is then followed up by X-ray examination every two months by Dr. Calthrop, and the majority of cases are found to clear up completely without further treatment. Dr. Calthrop also claims to be able to demonstrate the presence of adenoid tissue by X-ray photographs, and this method will undoubtedly take its place as an aid to diagnosis.

(6) *Nasal Catarrh and Nasal Diphtheria.*

Adenoid obstruction causes stasis of secretions from the nose and sinuses, and these are held up in the nasal passages. The mucus tends

to evaporate and become viscid, and forms an excellent breeding ground for organisms. Adenoidectomy usually cures the condition. In chronic nasal diphtheria, infection usually clears up completely after this operation.

(7) *Incomplete Adenoidectomy.*

If part of the adenoid tissue is left behind, it readily becomes infected. There are two common faults: pieces of adenoid tissue are left at either side and form adhesions with the Eustachian tubes, or the curette does not pass deep enough and only cuts off the tops of the adenoid folds. The former predisposes to deafness, the latter to abscess formation under the scarring which is bound to take place across the cut edges of the folds.

In my opinion it is much more important to remove the adenoid tissue correctly, and without injury to surrounding structures, than it is to perform tonsillectomy successfully. Both operations should, of course, be done with equal care. An incomplete tonsil operation, or damage to the throat, can easily be seen, but untold injury can be done in the naso-pharynx, and nobody but an expert will be any the wiser.

Large post-nasal polypi sometimes grow from the adenoid bed after imperfect adenoid removal in childhood. It is usually possible to remove these completely with an adenoid curette when removing the adenoid remnants.

TECHNIQUE OF OPERATION

Adenoidectomy will be discussed under the operation for the removal of tonsils, but it is as well to state here that adenoidectomy is often performed without the removal of the tonsils, particularly in the very young.

As a general rule, it is wisest to examine the tonsils carefully when performing adenoidectomy, and if they are suspicious, it is best to remove them at the same time. Children tend to suffer from tonsillitis after the removal of adenoids only.

A good deal of controversy has arisen over the question of removal of adenoids before or after tonsillectomy when complete operation is contemplated. Some surgeons prefer to remove the adenoids first. They claim that they are able to control hæmorrhage better, and that tonsillectomy is made easier. Others prefer to do the tonsils first. The writer prefers to do the tonsils first, because this method suits him best. He controls bleeding from the adenoid bed with swabs until all hæmorrhage has ceased. Either method should be equally effective in capable hands.

When using Sluder's technique the operation must always be done in sequence: First the right tonsil, then the left tonsil, and lastly the adenoids.

TONSILS

SURGICAL ANATOMY IN RELATION TO OPERATION

The tonsils lie, one on each side, at the entrance to the pharynx. Each is enclosed in a triangle of muscle tissue. Anteriorly lies the palato-glossus muscle (or anterior pillar of the fauces) and posteriorly the palato-pharyngeus (posterior pillar). The base of the triangle is formed by the tongue (fig. 2704).

The tonsil is often buried very deeply in the soft muscles of the palate, particularly at its upper pole. The lower pole usually protrudes into the pharyngeal cavity. The bed of the tonsil is made up of the superior constrictor muscle of the pharyngeal wall, with fibres from the palato-glossus and palato-pharyngeus interlacing across it.

The surgical anatomy has been described by Denis Browne (*Journal of Anatomy*), for whom the writer did all the illustrations and helped with the

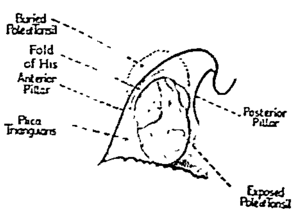

Fig. 2704.—The tonsil and the pillars of the fauces.

dissections. Denis Browne has pointed out that most of the bleeding during operation is of venous origin and is caused by tearing one or other of the large veins which run behind the capsule of the tonsil. These veins do not enter the tonsil itself but can become adherent to it after repeated attacks of inflammation, or resolution following paratonsillar abscess. The venous flow is from the upper pole towards the tongue, but brisk bleeding can occur from both ends if the vein is removed with the tonsil. Great care must therefore be taken to wipe these veins clear from the tonsil capsule during tonsillectomy. It is not easy to injure the great vessels of the neck during tonsillectomy because they lie deep to the constrictor muscles and are quite ¾-inch from the tonsil capsule, but disastrous accidents have occurred by using the scissors too freely in the tonsil bed.

When operating on old scarred tonsils in the adult, where the patient has suffered in the past from many quinsies, great care must be taken when dissecting away the fibrous tissue of the old abscess bed.

Aneurysm of the carotid artery in this position is very rare, but the writer has seen a case in a child of six years.

When removing the tonsils, whatever method is employed, the operation must

be complete, that is to say, the whole tonsil must be removed through the areolar layer which normally separates it from its muscle bed, and no part of its muscle bed must receive injury. It cannot be stressed too strongly that scar tissue, and destruction of muscle tissue in this area, can lead to severe disorganisation of the physiology of the nose and throat. Dreadful cases are sometimes seen, where the uvula and a large portion of the soft palate have been removed. The resultant contraction causes almost complete closure of the naso-pharynx. Every surgeon should aim at removing the tonsil without removing any muscle tissue at all.

The tonsil has a firm fibrous attachment at its base. The vessels and nerves which enter the tonsil do so near the tongue. The blood supply is provided by the external carotid artery, through branches of the lingual, facial, ascending pharyngeal, and the descending palatine branch of the internal maxillary artery. Here it is as well to bear in mind that an abnormally long styloid process can protrude right into the tonsil fossa, and has occasionally been removed at operation. It is also of interest to remember that certain congenital abnormalities are found from time to time. Remnants of the cervical sinus have been traced from openings in the neck to the supratonsillar fossa, and pus from a cervical abscess has been known to escape from this opening in the tonsil.

The tonsil is covered by mucous membrane only on its exposed surface, the mucous membrane dipping down to line the crypts. The surgeon starts his dissection where the mucous membrane stretches from the muscle of the pillars of the fauces to the edge of the tonsil (fig. 2704).

CLINICAL PATHOLOGY OF THE TONSIL

Congenital Abnormalities.

Occasionally, small islands of cartilage or bone are found on microscopic examination. These are probably remnants of the first and second branchial arches, and must not be confused with pieces of bone removed from the styloid process during tonsillectomy.

Foreign Bodies.

Fish bones or tooth-brush bristles occasionally stick into the tonsil and may not be recognised for several days. They can usually be palpated with the finger and removed. They may, of course, give rise to abscess formation. Calculi are sometimes found. These are probably the result of chronic inflammation in an obstructed crypt.

Inflammation.

(1) *Acute Surface Infections*

In this class we include Vincent's angina and diphtheria. In Vincent's angina the lesion is usually in the form of an ulcer with sloughing centre and highly-inflamed edge. The diagnosis is confirmed by finding the spirochæte and bacillus of Vincent from slides and cultures. Local application of trichloracetic acid usually clears up the condition.

In diphtheria the membrane is often confined to the tonsil, but may,

of course, extend to the fauces and palate. The greyish-white elastic membrane soon arouses suspicion, and K.L.B. are usually found without difficulty on culture of a piece of membrane. There is very little local reaction. There may be no hyperæmia of the mucous membrane. Treatment is, of course, by serum, and the condition must be dealt with at once on the clinical picture alone without waiting for the cultures. If, after the acute infection has died down, repeated swabs are positive, tonsillectomy will almost always clear up the infection. In diphtheria carriers the presence of K.L.B. in the throat can often be cleared up completely after tonsillectomy.

(2) *Acute Tonsillitis*

This may be divided into four sub-headings:

(a) *Catarrhal Tonsillitis.* This is a simple form of tonsillitis with lymphoid hyperplasia. It usually subsides easily, but may result in chronic hyperplasia and so necessitate tonsillectomy. The organism is usually one of the various forms of cocci found in the throat. Such tonsillitis usually takes place during an acute infection such as one of the exanthemata.

(b) *Acute Follicular Tonsillitis.* This is an acute infection, often localised to the tonsils themselves. The organism is usually the hæmolytic streptococcus. Yellow pus appears at the openings of the crypts, there is great local inflammation, and in severe cases there is œdema of the uvula and palate.

Tonsils should never be operated upon in this acute stage, or death from septicæmia may take place in a few days. Scarring from repeated tonsillitis will often lead to residual small abscesses in the crypts and necessitate tonsillectomy during a quiescent stage. It is best to allow a recovery period of about four weeks after a severe attack of acute tonsillitis before considering surgical removal.

(c) *Suppurative Tonsillitis.* A crypt becomes obstructed during an attack of acute tonsillitis and a small residual abscess is left behind. This may burst through the base of the crypt into the loose areolar tissue round the tonsil capsule, forming a paratonsillar abscess or a quinsy. The pus tracking along the tissue planes sometimes produces extreme swelling of the soft palate. This is red and inflamed. The patient is usually in great pain. It is best to postpone any attempt at opening the abscess until it has become properly localised, as otherwise severe [illegible] may result.

Some surgeons [illegible] until the abscess bursts of its own accord. If it [illegible] be done

through the point of maximum fluctuation. It is best performed by anæsthetising the surface with a small swab of cocaine, making a tiny cut, and then opening the abscess with sinus forceps. A patient suffering from hæmophilia has been known to die from hæmorrhage after the spontaneous bursting of a quinsy (Hollick).

Tonsillectomy should be deferred for at least a month after recovery.

(*d*) *Gangrenous Tonsillitis.* Occasionally, whole areas of tonsil tissue may be sloughed away. Very severe hæmorrhage may result. Any question of tonsillectomy must be deferred until several weeks after the condition has subsided.

(3) *Chronic Inflammation of Tonsils*

(*a*) *Non-Specific.* Chronic hyperplasia may follow acute catarrhal inflammation, or scarring may result from an acute follicular infection. It is common in cases like this to find tiny abscesses deep within the crypts. These tend to discharge pus when the tonsil is massaged by the act of deglutition. The crypts often become obstructed by dead epithelium, which is highly offensive. The crypts contain concretions of necrosed desquamated epithelial cells, and there is considerable polymorphonuclear infiltration round the crypts. The patient experiences a sense of discomfort and irritation.

Many types of organism may be grown—streptococci of all kinds, staphylococci, micrococci and diphtheroids. Keratinisation of the surface of the tonsil sometimes takes place.

(*b*) *Specific.* Streptothrix actinomyces is found on routine examination in a few cases of chronic tonsillitis. In diphtheritic carriers K.L.B. can be found in the tonsil crypts, and occasionally areas resembling diphtheritic membrane are seen inside the crypts on microscopic section. Tuberculosis of the tonsil occurs more often than is generally supposed.

In all cases of chronic cervical adenitis where tuberculosis has been suspected or found, it is advisable to examine the tonsils under the microscope and to inject an emulsion into a guinea-pig. In a large percentage of these cases we have found tubercle bacilli in the neck abscess, and have been able to demonstrate the bacilli or the presence of tubercles in the tonsil tissue. It must be remembered that this type of tonsil often looks quite innocent when examined clinically.

Gummata of the tonsil sometimes occur, and if the gumma breaks down a suspicious-looking ulcer will make its appearance. In all cases of ulceration or tumour formation in the tonsil it is as well to know the Wassermann reaction.

CYSTS OF THE TONSIL

Small cysts are fairly common in the tonsil. They often give rise to no symptoms. They appear as white or yellowish-white cystic swellings with occasional blood-vessels running across them. They are often about the size of a pea, but one cyst which the writer removed whole with the tonsil in a man of 27 measured 3×3 cms. The cysts are lined by squamous epithelium, and contain sebaceous material, or brown pultaceous matter in which are to be found cholesterol crystals.

TUMOURS OF THE TONSIL

(1) *Simple Tumours.*

Papillomata are sometimes found. These are branched squamous-celled papillomata, and chronic inflammation is usually present in the tonsil. Polypi are occasionally seen. Cartilaginous tumours are rare, but do occur. A good specimen of lymphangioma of the tonsil is preserved in the London Hospital museum.

(2) *Malignant Tumours.*

Lympho-sarcomata and squamous-celled carcinomata are occasionally seen. The sarcomata are usually of the lympho-fibro-spindle-shaped type, and sometimes occur in young people.

The carcinomata are squamous, prickle polygonal, and occasionally horny-celled. They usually occur in patients over fifty.

Sarcomata usually appear clinically as smooth, solid tumours, whereas carcinomata often break down to form ulcers with everted edges and hard fixed surrounding areas.

Secondary glands in the neck are often present, and may be the first sign of the presence of a malignant growth. It must be remembered that there may be no glandular enlargement whatever.

A rare form of neoplasm is a primary malignant endothelioma of the tonsil.

INDICATIONS FOR OPERATION

These may be divided up into two headings:

(1) Local conditions in the tonsil.

(2) General conditions arising in the body from the absorption of toxins or organisms from the tonsil.

Under the heading of local conditions requiring tonsillectomy may be placed chronic hyperplasia causing obstruction, and this is most commonly found between the ages of four and six. When considering the question of tonsillectomy it must be remembered that the tonsils appear to become enlarged in all children between the ages of four and

six. There is often a slight enlargement at puberty, but after that any enlargement must be considered as pathological.

Any chronic local infection of specific or non-specific origin, and repeated attacks of acute tonsillitis or quinsy, call for tonsillectomy. Tuberculous tonsils should be removed, but gummata are best treated with general anti-syphilitic measures.

Cysts of the tonsil seldom cause symptoms unless they are unduly large, but as they are probably the result of chronic inflammation tonsillectomy is advisable.

Most new growths of the tonsil should be treated by tonsillectomy.

In trying to assess the indications for and against tonsillectomy, the age of the patient is of great importance. In the child, more attention must be paid to clinical signs and symptoms—such as obstruction, enlarged glands, repeated colds and catarrh—than to the appearance of the tonsils themselves. In older persons, the comparative severity of the operation must be borne in mind.

GENERAL DISEASES ATTRIBUTED TO ABSORPTION FROM THE TONSILS

Almost all chronic infections, even though they exist in different parts of the body, have been put down to absorption from the tonsil.

When the physician is looking for a primary focus during the treatment of a difficult and chronic disease, it is only natural that his eye should fall upon the tonsil if there are any signs or symptoms of chronic inflammation or of repeated acute inflammations in that complicated structure where organisms of all kinds can so readily be grown.

Our present conception of the physiology of the tonsil is incomplete. The writer is studying this problem very closely, but beyond the fact that the crypts always contain organisms, and that lymphocytes and leucocytes can be seen wandering through the mucous membrane lining the bases of the crypts, where they obviously come into close contact with these organisms, it is impossible at the present stage of our knowledge to be dogmatic. It is probable that the tonsil, at any rate in early childhood, enables the body to immunise itself against the organisms of its environment.

As we progress with our civilisation, with its overcrowding and air pollution, it seems probable that the sieve-like mechanism of the tonsil breaks down and that organisms are allowed to enter the general circulation, or that, when organisms find a suitable culture medium in the tonsil, the threshold of absorption of toxins is lowered. As an

example—acute hæmorrhagic nephritis in childhood is often cleared up completely by the removal of the tonsils.

Tonsillectomy is likewise advocated for rheumatism in childhood or in the adult, particularly when each attack of rheumatism is heralded or succeeded by an acute inflammation of the tonsils. It will be seen that tonsillectomy may often be very helpful in some forms of malnutrition, indigestion, or persistent rise of temperature. In all cases the clinician should attempt to link up the general condition with signs of chronic inflammation in the tonsil It is interesting to note that toxicity of the thyroid gland is often associated with tonsillitis, and that acute thyrotoxicosis is often ushered in by an acute infection of the tonsil.

PREPARATION FOR ALL TYPES OF OPERATION ON TONSILS AND ADENOIDS

The most important factor in any operation is the patient, and the child in particular should be treated like a normal human being. It is well worth while giving attention to the patient's mental outlook. Children are intelligent little people, and may justly demand an intelligent outlook on the part of the surgeon, the anæsthetist and the nurse. Strange faces and unusual happenings breed anxiety and apprehension in the wondering child faced with an adventure into the unknown. The surgeon will rise or fall in the parent's eyes according to the child's reactions The adventure should be made something of a game, and friendship and understanding should be brought into the pre-operative atmosphere. The child should be given normal food up to the day of operation, but the fat intake should be limited for the preceding day or two. A little barley sugar added to the meals is helpful, and combats ketosis. A mild aperient should be given the night before if the bowels are not regular. The urine should be tested. The last meal should be taken two or three hours before the operation, and should consist of a cup of Bovril or a glass of skimmed milk with dry toast or plain biscuit.

It is a good plan to operate upon both children and adults in the early morning. In the adult a good night's rest should be assured.

The history should be carefully considered, particularly with relation to hæmophilia or a tendency to bleed.

Anæsthesia.

Every surgeon operating on the nose and throat should have a working knowledge of anæsthesia. An intimate and happy co-operation helps both surgeon and anæsthetist immeasurably, reduces the time taken, and minimises shock to the patient. It must be remembered that both surgeon and anæsthetist are working in the same field.

If the child is apprehensive and of a nervous disposition, a basal anæsthetic can be given. Nembutal and avertin are used by some surgeons, but by far the safest for children is paraldehyde per rectum. The child's bowel is washed out on the morning of the operation, and two hours before the operation is due to start the paraldehyde is introduced gently into the rectum so that the child will retain it. One drachm per stone body weight of paraldehyde in a few ounces of saline or of soya bean oil is the dose advocated by Sington. The solution should be alkaline. The child goes to sleep in his bed. He can be roused on stimulation and has all his reflexes, but will remain unconscious of his surroundings. There is always a slight rise in pulse-rate with paraldehyde, and this must be taken into account, particularly during the post-operative period. Used carefully, paraldehyde is absolutely safe. A basal anæsthetic is contra-indicated in the presence of kidney disease or metabolic disturbances.

Atropin is given hypodermically half an hour before the operation. When all is ready for the operation, the anæsthetist induces the child with a little ethyl chloride or gas and oxygen. In the operation by dissection in childhood a fairly deep anæsthetic is required, the administration of which commands a considerable degree of skill. When a basal anæsthetic has been used, the child may struggle a little in a half-conscious manner, but will retain no memory of the induction. When no basal anæsthetic has been used, patience and an understanding of child psychology will be required during the induction if the child is not to retain unhappy memories of suffocation. After induction, oxygen is bubbled through ether and the gases are carried to the child's pharynx by a length of rubber tubing, to the end of which is fitted a hollow metal hook fitting gently into the mouth. When Sluder's method with the guillotine is used, a very short anæsthetic is required. As soon as automatic breathing has started, the anæsthetic ceases and the operation begins. A basal anæsthetic is usually inadvisable.

If a skilled anæsthetist is available, intra-tracheal anæsthesia may be used with gas and oxygen. As, however, the tube passes through the nose and naso-pharynx to reach the trachea it may be obstructed by a large mass of adenoid tissue. The tube must be withdrawn before the adenoid tissue can be removed, and this is often inconvenient if the operation has to be prolonged.

OPERATION

Choice of Technique.

It is a very easy matter for the unskilled operator to leave pieces of tonsil behind. Buried tonsils, or tonsils which have been scarred by

disease or previous surgery, are best removed by dissection. Adult tonsils are best dissected. My own preference is for the method of gentle dissection in childhood, first described by Waugh in 1909. This can be used for every type of child and tonsil, and answers all requirements. It is quick, gentle and efficient, and there is a minimum loss of blood, but it requires perfect skill and balance and an appreciation of the delicate structures in relation to the tonsil. The beginner may easily get into grave difficulties with this operation, and a clumsy operator can cause untold damage. All too often the operator is launched out upon a career of tonsillectomy without adequate preliminary training under strict supervision. The pupil must be made to master the art of working in the throat and must be taught the steps of each operation in sequence. In the adult I would advise dissection, but a slightly different technique is employed. It cannot be too strongly emphasised that although removal of tonsils can be a comparatively simple matter in the hands of the expert, it can become one of the most difficult operations in surgery.

The best technique is that which ensures the best results. In children some surgeons prefer the Sluder method of removal of tonsils with a guillotine. Others prefer Waugh's method of dissection. The surgeon should use the technique best suited to the individual case. All surgeons develop an individual technique, no matter what method they employ. We are all fashioned in different moulds, and the balance of our bodies, arms and fingers governs the choice of instruments we use and the position we adopt at operation. The ideal combination should aim always at the gentle, clean removal of the tonsils and adenoid tissue without damage to the anatomy or physiology of the throat. The tonsils should be removed completely.

The Sluder operation is best suited to that type of tonsil which protrudes into the pharynx from its fossa. Its use is mainly confined to the removal of tonsils in childhood. A skilled operator finds this method perfectly satisfactory, but the guillotine can cause considerable damage if used carelessly.

Removal of Tonsils by Sluder's Operation.

This method should be used solely for children. Buried tonsils are best dissected.

The child is placed on his back on a fairly high table, his body wrapped in a blanket. No sand-bag is required. A gag is placed in the mouth. There must be a good overhead light or the surgeon must wear a headlight. The surgeon, if right-handed, stands on the right of the patient facing the child's head. The anæsthetist steadies the head.

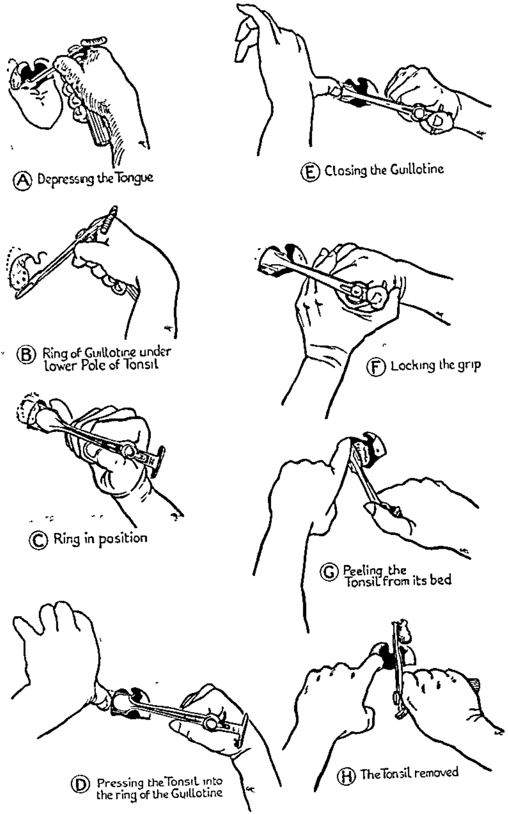

Fig. 2705.—TONSILLECTOMY BY SLUDER'S OPERATION.

The sister in charge holds the patient. The guillotine is selected, according to the size of the child and the tonsil, and held in the right hand. The blade is drawn back and the tongue depressed (fig. 2705A). The ring of the guillotine is passed under the lower lobe of the child's right tonsil (fig. 2705B). With the thumb or forefinger placed on the anterior pillar, the guillotine is brought into a position horizontal with the child's body (fig. 2705C). Care must be taken not to include the uvula. At the same time the tonsil is pressed into the loupe of the guillotine and the ring of the guillotine pressed up against the thumb.

It must be remembered that a large portion of the upper pole of the tonsil may be buried and this has to be pushed out into the ring if the tonsil is to be removed completely (fig. 2705D). With the pressure of both hands maintained, the blade is closed gently but firmly, care being taken to avoid the inclusion of the anterior pillar (fig. 2705E). The thumb on the anterior pillar can now be withdrawn and can be used to assist the right hand in maintaining pressure on the blade (fig. 2705F). Pressure on the blade must never be relaxed once the blade has been closed, as otherwise part of the tonsil will slip out as it is withdrawn from its bed. With a sharp upward movement of the closed guillotine the tonsil is removed from its bed. The use of the left finger to protect the pillars of the fauces as the tonsil is withdrawn is a great advantage (figs. 2705G and 2705H).

The operator now withdraws the guillotine with the tonsil attached to it. The blade is opened, the tonsil placed in a dish, and the surgeon now takes up a position facing the child's feet. The ring of the guillotine is placed under the lower pole of the left tonsil and the same procedure is adopted.

Both tonsils have now been removed. The child is at once placed on his side to allow the blood to drain away. A finger is inserted into each fossa to make sure that it is clean and that no extra lobe of tonsil has been left behind. A small piece of tonsil will easily grow to an alarming size if left behind, and is a source of great disappointment both to the parent and to the surgeon, condemning the child to a second operation later on.

The adenoids have now to be removed. With the child on his side, a curette of the St. Clair Thomson type complete with guard is selected. A finger in the naso-pharynx will soon tell the surgeon what size to choose, and his judgment will be largely guided by the distance apart of the Eustachian pillars.

The blade of the curette is passed behind the uvula and the soft

palate, until it reaches the vomer. It is gently slid down the vomer, keeping to the middle line until it engages the adenoid tissue. With the head held steady, and the left thumb as a movable fulcrum, the right hand holding the adenoid curette maintains firm gentle pressure on the adenoid bed as the blade is drawn through. A sense of touch is gradually developed which enables the surgeon to remove the adenoid tissue complete with a minimum of trauma, but considerable experience is required before this touch is developed.

The adenoid bed does not form a simple curve. The first half is bony, and is fairly flat with the base of the skull. The second, or muscular half, curves gently upwards towards the base of the uvula. The bed is thus concave in a longitudinal direction, but it is also slightly convex laterally. The adenoid tissue may slip out of the curette at the end of the sweep, but a finger placed on the posterior wall of the pharynx will prevent this from happening.

A short period of brisk hæmorrhage now takes place. The finger is again placed in the naso-pharynx to ensure complete removal of the adenoid tissue, and it will often be found that large folds have been left on either side near the Eustachian tubes. Remembering that the bed is convex from side to side, these folds, if they be present, are removed with a clean curette. Hæmorrhage is controlled by douching the face with iced water, and the airway must be kept clear of blood by mopping this out and keeping the head low. When all hæmorrhage has ceased, the child is taken to the recovery room and placed on a couch on his right side, with the foot of the couch raised.

It is naturally more satisfactory to admit all cases after tonsillectomy, for one night at any rate, but it is the practice in some hospitals to allow the parents to carry the child home to bed, after careful examination to ensure cessation of bleeding and complete recovery from anæsthesia.

Dissection in Childhood.

A small sand-bag is placed beneath the child's shoulders. The gag is placed between the left molar teeth, the lower jaw gently raised with the fingers of the left hand, and the gag opened. Care must be taken to ensure that the lips are free.

Tongue forceps are placed on the child's tongue in the middle line, about ½-inch from the tip. Gentleness will greatly diminish post-operative discomfort. An assistant holds the forceps and keeps the chin raised.

A little gauze is placed in each nostril. Where open anæsthesia is used, this prevents the entry of air through the nose. Should much

bleeding follow removal of the adenoids, this will prevent the blood from trickling from the nostrils into the eyes.

The surgeon stands on the right-hand side of the child, bending slightly over the mouth. For illumination a headlight may be used, or, if the operation is performed in a clinic, a well-focussed scialitique

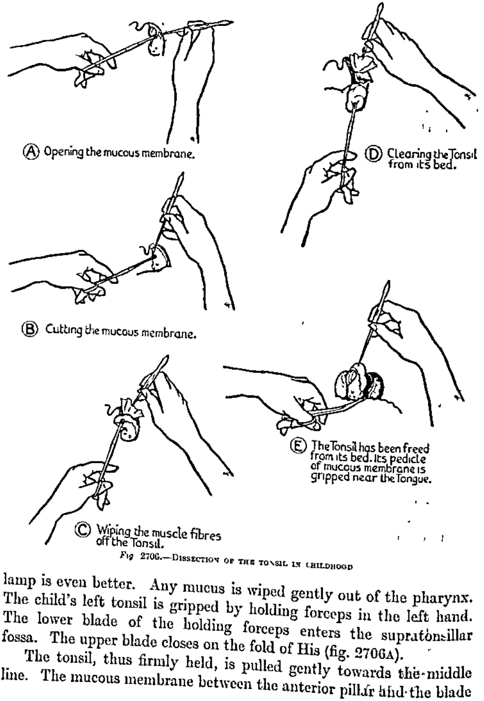

Fig 2706.—Dissection of the tonsil in childhood

lamp is even better. Any mucus is wiped gently out of the pharynx. The child's left tonsil is gripped by holding forceps in the left hand. The lower blade of the holding forceps enters the supratonsillar fossa. The upper blade closes on the fold of His (fig. 2706A).

The tonsil, thus firmly held, is pulled gently towards the middle line. The mucous membrane between the anterior pillar and the blade

of the forceps is gently picked up by fine-toothed forceps held in the right hand, and a small tear is made. At once the glistening capsule of the tonsil is visible. The closed points of the fine dissecting forceps are run gently under the mucous membrane towards the uvula, round the upper pole of the tonsil, and down along the posterior pillar (fig. 2706B).

The mucous membrane is easily torn through close to its attachment to the tonsil. The forceps are withdrawn and the mucous membrane round the lower pole is separated from the tonsil in the same way. All this time a firm grip is kept on the tonsil with the holding forceps. The muscle-fibres of the anterior pillar are now gently separated from the tonsil. When the capsule has been sufficiently exposed, a new grip is taken by holding forceps (fig. 2706C).

With the help of dry gauze the muscles of the tonsil bed are wiped off the capsule and the tonsil eased still further towards the middle line by the holding forceps. Care must be taken in wiping off the muscle-fibres at the upper pole to prevent injury to the posterior pillar. As the tonsil fossa becomes exposed, the paratonsillar veins will often be seen, and must be wiped away from the tonsil capsule with great care. A gauze swab is gently but firmly placed into the fossa. Dissection is often held up by a band of fibres which run from the angle formed by the anterior pillar and the tongue, and these should be separated with scissors if necessary. Harsh traction on these fibres will buttonhole the anterior pillar. A dry swab is eased down the posterior pillar, wiping off the remaining muscle-fibres (fig. 2706D).

The tonsil is now completely enucleated except for its attachment by mucous membrane along the tongue. With a gentle twist of the left hand this is easily separated. In the majority of cases there is extremely little bleeding. As long as the depth of anæsthesia is satisfactory, the gauze swab already placed in the tonsil fossa will control all hæmorrhage.

The surgeon now changes his position to the left side of the child. The holding forceps are held in the right hand, the dissecting forceps in the left. The right tonsil is now removed in exactly the same way.

It is obvious that the surgeon must be to a certain extent ambidextrous for this operation, but skill is easily acquired with practice.

Both tonsils have now been removed, and each tonsil fossa is already fairly firmly packed with a gauze swab.

Throughout this operation the airway must be kept clear. This is of primary importance. If the anæsthetic is too light, the child will gag and the gauze swabs will not be retained in the tonsil fossa. Troublesome bleeding may result, and the surgeon must always control this

bleeding with the use of swabs, held firmly in the forceps, until the anæsthetist can get the child quiet again.

The surgeon now sits at the head of the table and examines each fossa in turn. If a small remnant of tonsil is present this is removed, and if the lingual fold has been left behind during dissection this is now removed by grasping it with the holding forceps and gently separating it with dissecting forceps.

All bleeding points must now be found and ligatured. In the majority of cases in childhood there is no need whatever to ligature bleeding

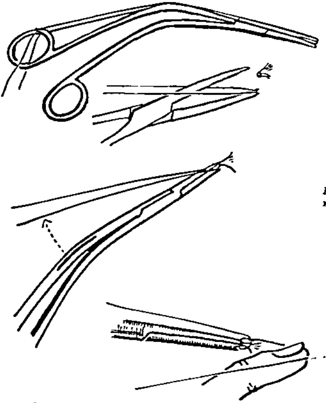

Fig. 2707.—Ligature of oozing blood-vessel with the aid of Browne's forceps.

vessels. Skilled dissection and comparatively deep anæsthesia will reduce hæmorrhage to a minimum. Torn veins and cyanosis are responsible for bleeding. When bleeding occurs, a good knowledge of the surgical anatomy of the tonsil bed is of great use to the operator. The points which most commonly bleed are seen in figure 2708. The fossa is mopped with gauze, and the bleeding point identified and ligatured (fig. 2707). The ligaturing of vessels after tonsillectomy can be a source of great anxiety to the surgeon. This is one of the branches of his art which he should make a point of mastering early in his career. Nothing gives a surgeon greater confidence than the knowledge that he can cope with any bleeding at any time. It is a skill rapidly acquired

with practice, and is worth acquiring because it reduces the time and danger of the operation.

The surgeon now proceeds to remove the adenoids. The writer prefers to have the child well under the anæsthetic for this part of the operation. If the naso-pharyngeal sphincter is relaxed, there is less danger of tearing the superior constrictor, bleeding can be more readily controlled, and the operation more accurately performed.

A finger is first placed under the soft palate and the adenoid bed palpated. I use a curette of the St. Clair Thomson or Twistington Higgins type. No guard is used, and the blade must be kept extremely sharp. The size of the curette required is determined by the distance apart of the Eustachian tubes. The blade of the curette is passed under the soft palate until it reaches the vomer. The curette is held in the right hand and gentle pressure is exerted in a downward position. The left thumb forms a movable fulcrum, and the blade is swept gently forwards and upwards through the adenoid bed. The adenoid tissue can often be brought out balanced on the bare blade, or is picked out of the naso-pharynx with forceps.

Hæmorrhage is sometimes brisk, but can be controlled by packing a swab quickly into the naso-pharynx and pressing downwards at a point opposite the base of the uvula where the two large veins run between the heads of the longus capitis muscle (see fig. 2703c).

Any folds of adenoid tissue left behind are now removed by running the blade of the curette under each Eustachian tube, great care being taken not to injure the tubes in any way. A search is made for intranasal extensions of adenoid tissue.

Reference to the surgical anatomy of the adenoid bed will be of the greatest assistance (see figs. 2701 and 2703).

When all hæmorrhage has ceased, a nasal catheter may be passed down each nostril to make sure that the airway is clear. The anæsthetic can usually be stopped as soon as the adenoid tissue has been removed, and plain oxygen given whilst the surgeon is waiting for all hæmorrhage from the adenoid bed to stop.

A finger is now placed down towards the larynx, into each tonsil fossa and into the naso-pharynx, to make sure that no swabs have been left behind. If the surgeon makes this examination a habit it will save him endless worry. The gag is now removed, and the child is placed on his right side—upper leg strongly flexed, lower leg extended—and is carried back to bed. A nurse should be in attendance until the child has fully recovered from the anæsthetic, and this is very important in children who have had some form of basal anæsthesia.

The tongue forceps should be kept on until all reflexes have returned. Saliva should be mopped out.

If preparation has been adequate, children seldom vomit, but great care must be taken to keep the airway clear if vomiting takes place before complete consciousness has returned.

TONSILLECTOMY IN THE ADULT

This is almost invariably performed by dissection, and in this country general anæsthesia is most commonly used. The anæsthetic is administered by the endotracheal route, the tube passing through the nose. Gas and oxygen with a little ether is very satisfactory in skilled hands. If a Boyle-Davis gag is used, endotracheal anæsthesia is not essential, and O_2 bubbled through ether, with perhaps a little chloroform, can be administered down the metal tube attached to the tongue-piece of the gag. The anæsthetist should aim at having the field of operation well relaxed, thus enabling the surgeon to control bleeding much more easily.

Where endotracheal anæsthesia is used, the hypo-pharynx may be packed off with a gauze swab, but if open anæsthesia is used the surgeon must always bear in mind that blood can easily enter the larynx on inspiration. A suction apparatus may be used to remove any blood which may collect in the field of operation. The surgeon, as a rule, sits at the head of the table and wears a headlamp, or head-mirror with reflected light.

All mucus is removed from the pharynx, and the tonsil is gripped by the holding forceps. Scissors or fine forceps are used to separate the mucous membrane where it is reflected from the anterior pillar on to the tonsil surface. It is usually best to start the incision close to the holding forceps with the tonsil firmly retracted towards the middle line. The mucous membrane is cut through round the apex of the tonsil, near the uvula, and upwards towards the tongue.

The grip with the holding forceps is then changed to the apex of the tonsil, and with the aid of gauze dissection the muscle-fibres of the tonsil bed are separated from the tonsil capsule, the tonsil itself being held firmly away from its bed and retracted in the direction of the larynx. If the posterior pillar is left intact until the whole tonsil has been freed from its bed, hæmorrhage can be much more easily controlled. Scissors will almost certainly be needed to cut through the attachments of the tonsil near the tongue, and when the patient has suffered in the past from paratonsillar abscess, the fibrous bed of the abscess will have to be dissected up. The posterior pillar can easily be separated off the tonsil, when required, with one wipe of a gauze swab.

The tonsil is now attached only at the base of the tongue and further dissection will free it completely. A snare may be used at this point for separating the tonsil from the tongue. It must be remembered that the blood supply enters the tonsil itself at a point marked II in figure 2708.

The veins of the tonsil bed (fig. 2709) lying outside the capsule of the tonsil are easily torn in cases where there has been chronic sepsis with fibrosis. Particular attention must be paid to bleeding points which appear surrounded by fibrous tissue, because these vessels do not retract easily and their mouths are held open by the fibrous tissue. *Veins such as these give rise to reactionary hæmorrhage.* When ligaturing vessels, care must be taken not to let a vein retract beneath muscle-

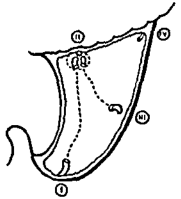

Fig. 2708.—THE BLEEDING POINTS OF THE TONSIL IN THEIR ORDER OF IMPORTANCE. VESSELS ENTER TONSIL HILUM AT (II).

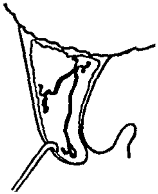

Fig 2709—THE VEINS OF THE TONSIL BED. DRAWN ACCURATELY FROM LIFE

fibres as it is sometimes extremely difficult to find the bleeding point, and it is therefore advisable to tie them off as soon as they are seen.

When all bleeding has been stopped, the instruments change hands and the second tonsil is similarly removed. Care must be taken not to leave any swabs behind in the tonsil fossæ or naso-pharynx, and all hæmorrhage must have ceased from both fossæ before the gag is removed.

The patient is then placed on his side, tongue forceps are placed on the tongue, and the airways kept clear while he is recovering from the anæsthetic. If endotracheal anæsthesia is used he can go back to bed with the tube in place, this being removed later by the anæsthetist.

Operation by Diathermy.

Malignant new growths are, of course, dissected out by the diathermy knife, leaving an adequate margin between the growth and the

adjacent normal tissues, but the diathermy knife is sometimes used for dissection in cases when no malignant growth is present. It has certain advantages in that bleeding is more easily controlled, but the surgeon must be on the look-out for secondary hæmorrhage. Unless great care is used, rather more scar tissue will be found during the process of healing than is the case after dissection with the usual instruments. When using diathermy for malignant growths it is advisable to ligature the external carotid on the affected side. Where new growths of the tonsil can be removed by diathermy without severe injury to the pharynx and subsequent loss of function, this is probably the safest method of treatment. If, on the other hand, the patient is likely to be left severely crippled by an extensive removal, it is wisest to use irradiation by radium or deep X-rays

Destruction of the tonsil by diathermy, as opposed to its dissection by the diathermy knife, is sometimes advocated. It must be remembered that only a relatively small part of the tonsil can be destroyed at a time, and that the patient will have to undergo five or six applications at different sittings. The operation is usually performed under local anæsthesia. It is a method used chiefly in patients who are poor subjects for general anæsthesia, or in serious infections of the heart, lungs or blood stream.

Dissection under Local Anæsthesia.

In England, where skilled anæsthetists capable of administering general anæsthesia with a considerable margin of safety are available, local anæsthesia is comparatively seldom used. It has its advantages in patients for whom general anæsthesia is contra-indicated. It is very popular in America and on the Continent of Europe.

The patient sits in front of the operator with an attendant holding the head. A tongue depressor exposes the tonsil area and this is swabbed several times with a 10 per cent solution of cocaine and adrenalin. No excess of the solution must be allowed to collect in the mouth where it can easily be swallowed. A $\frac{1}{2}$ per cent solution of novocaine is injected from a syringe with a big needle, about five injections being made in all. It is the aim of the surgeon to inject the solution into the loose areolar tissue dividing the tonsil from its muscular bed, and the needle point is inserted at intervals between the muscle tissue of the anterior and posterior pillars and the body of the tonsil. In other words, the local anæsthesia should be injected into the plane through which the tonsil is separated from its bed during dissection. The patient should then be left for 10 minutes before dissection is started.

This operation is not without its dangers, because apart from the

sensitivity of some patients to cocaine, and of others to the injection of novocaine into the tissues, there is always the risk of the patient losing his nerve during a severe hæmorrhage.

POST-OPERATIVE COMPLICATIONS

(1) *Hæmorrhage.* This may be primary, reactionary, or secondary. If all bleeding points are properly ligatured, primary hæmorrhage should not occur. In all cases of tonsillectomy a half-hourly pulse chart should be kept by the nurse. Primary and reactionary hæmorrhage usually occur after difficult anæsthesia, particularly when cyanosis has been present during the operation. Good oxygenation of the patient is therefore essential during the whole operative period.

It is sometimes difficult to ascertain whether hæmorrhage is taking place in a child after the removal of its tonsils. It is just as well to remember that in a child who is bleeding after the removal of tonsils and adenoids, the blood must be in one of two places: It will either ooze out of the mouth or nose where it will be easily recognisable, or it will be swallowed and remain in the stomach, whence it is usually vomited from time to time. The writer knows of a case where hæmorrhage was missed until blood was passed per rectum. Although, in this case, the pulse-rate went up and the child was blanched, the nurse had not reported the rise to the R.M.O., because she was quite certain that there had been no visible bleeding from the mouth or nose, and the child had not vomited.

A child who is bleeding is usually restless, and if closely watched will be seen to swallow from time to time. If, after careful examination of the throat, the surgeon is in doubt, a finger on the back of the tongue will usually make the little patient vomit, and the presence of blood in the vomit will confirm the suspicions of hæmorrhage.

All vomited matter should be kept until examined by a responsible person, and any sign of bleeding should be immediately reported to the surgeon. Children cannot afford to lose much blood, and if bleeding is suspected immediate measures must be taken to control hæmorrhage.

If bleeding is coming from the adenoid bed, a gauze swab placed in the naso-pharynx for a few hours will stop the loss of blood. No anæsthetic is, as a rule, necessary, but the gauze must fit snugly into the naso-pharynx as otherwise it will become dislodged. A piece of silk thread may be attached to the gauze swab.

If hæmorrhage is taking place from the tonsil beds, it is wisest to give the child a second anæsthetic immediately. It is usually an easy matter to find the bleeding point and arrest the hæmorrhage with a

ligature, and children tolerate a second anæsthetic of plain ether very well. Blood can be sucked out of the throat with a suction apparatus during induction.

If the decision to give a second anæsthetic is delayed too long, the child may be in grave danger and a blood-transfusion may be necessary after the vessels have been ligatured.

In the adult suffering from primary or reactionary hæmorrhage from the tonsil bed, it is often more satisfactory in the long run to ligature the bleeding points under a second anæsthetic. If an adult is given morphia or some other sedative on coming round from the anæsthetic after removal of tonsils, reactionary hæmorrhage seldom occurs. In some cases of slight hæmorrhage following tonsillectomy, morphia will quieten the patient and hæmorrhage will cease. Local application of gallic and tannic acid, or the use of a tonsil clamp, may be tried after the clot has been cleaned out from the tonsil fossa. The surgeon will seldom regret a decision to take the patient back into the theatre, where hæmorrhage can be speedily and accurately stopped by ligature, unless he waits too long before making up his mind.

Secondary hæmorrhage usually occurs on or about the sixth day and is due to infection in the tonsil bed. Secondary hæmorrhage is seldom dangerous, although it can be very alarming to the patient. It is best treated conservatively because it is often a matter of extreme difficulty to ligature a bleeding vessel in a mass of necrotic tissue.

(2) *Septicæmia.* This is fortunately a rare complication. If due care is taken to avoid operation during an acute infection, septicæmia should not take place. In a hospital ward patients occasionally develop septicæmia after tonsillectomy if they are nursed in contact with patients suffering from tonsillitis or sinusitis.

(3) *Lung Abscess.* This is a very rare complaint in this country. Its appearance is more common where local anæsthesia is used extensively.

(4) *Middle Ear Disease and Mastoiditis.* The ear should not become infected after adenoidectomy or tonsillectomy, but very occasionally, if the child has come in contact with cases of infection during its recovery period, otitis media develops.

(5) *Exanthemata.* Children, following tonsillectomy, occasionally develop scarlet fever, measles, or whooping-cough. It is difficult in these cases to be certain whether or not the child was incubating these diseases at the time of operation.

Two cases have been reported (Collis) where two children related to one another developed an acute form of scarlet fever and died within

three days of tonsillectomy. They had both been in contact with a virulent case of scarlet fever the day before the operation.

Every care must therefore be taken to avoid operating upon children with recently-developed colds or pyrexia.

(6) *Tonsil and Adenoid Remnants.* Very little benefit will be gained from the operation unless the tonsils and adenoids are removed efficiently. This question has already been dealt with fully. If the nose and throat are examined very carefully at the time of operation, remnants will not be left behind. Small remnants grow rapidly, become infected, form abscesses and scar tissue, and are often a worse menace to health than untreated tonsils and adenoids. Even in these days, one so often hears of children undergoing two, three, or even more operations for the removal of their original tonsils and adenoids. Surely this is nothing short of a disgrace to the medical profession. It is unfair to the child, innocently unaware of surgical weaknesses, and it is unfair to those who have placed in the surgeon's hands the greatest of all human trusts—the health and happiness of a little child.

PART XXX
TONGUE, MOUTH AND LIPS

by
STANFORD CADE

TONGUE, MOUTH AND LIPS

CHAPTER I

Embryology and Anatomy of the Mouth and Tongue

DEVELOPMENT

Between the overhanging head and the pericardium of the developing embryo is formed the oral recess. The floor of the recess comes in contact with the anterior prolongation of the foregut, and the junction of the ectoderm of the former with the endoderm of the latter forms the primitive bucco-pharyngeal membrane. This becomes perforated in the third week. The ectoderm gives rise to the characteristic *squamous-celled epithelium lining the mouth*, and the original columnar ciliated epithelium of the endoderm is transformed into the epithelium covering the posterior part of the tongue and the adjoining portions of the pharynx and pillars of the fauces. At the same time as the bucco-pharyngeal

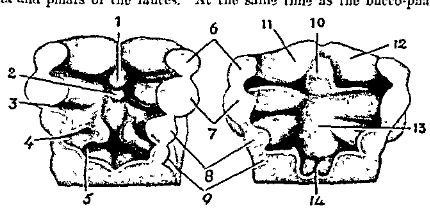

Fig 2710—Floor of mouth of 4–5 mm long embryo.

1 *Tuberculum impar* v *medium.*
2. Foramen cæcum.
3. Tonsillar recess.
4, 5. Pharyngeal pouch.
6. Mandibular arches
7. Hyoid arches
8 Third branchial arches
9. Fourth branchial arches
10. Tuberculum medium.
11, 12. Tubercula lateralia.
13 Copula.
14 Rima glottidis.

(From Peter's models, after Fuchel)
(From "Diseases of the Tongue," Spencer and Cade, H K Lewis, 1931)

membrane perforates, there appear the mandibular and maxillary processes. The mandibular processes grow forward from the wall of the primitive pharynx, one on each side, to meet and fuse in front. Immediately behind the union of the two mandibular processes, in the mid-line of the floor of the oral cavity, a mass of mesodermal tissue grows upwards; this is the *tuberculum impar* from which a part of the anterior or buccal part of the tongue is developed—the area in front of the *foramen cæcum* and the V of the *circumvallate papillæ (fig. 2710).* The lateral and posterior portions of the tongue develop from the fusion of the two lateral lingual tubercles which are derived from the second, third, and possibly the fourth branchial arches.

The musculature of the tongue is derived from somites around the neural

canal and notochord. The nerve supply of the tongue is derived from: (1) the nerve of the mandibular arch—the fifth cranial nerve; (2) the nerve of the first branchial cleft—the chorda tympani; (3) the nerve of the third arch—the glosso-pharyngeal nerve; and (4) the nerve to the cephalic segments giving rise to the musculature—the hypoglossal nerve. Behind the foramen cæcum, in the human embryo, is developed the tuberculum thyroideum (fig. 2711). The thyroglossal tract originates

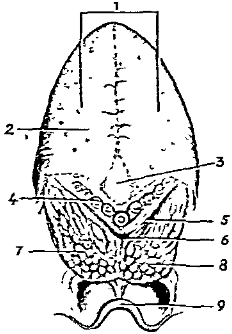

Fig. 2711.—SURFACE OF TONGUE—AREAS OF DIFFERENT FORMATION.

1, 2. By tuberculum laterale.
3. By tuberculum medium v. impar constituting the area rhomboidea mediana.
4. Circumvallate papillæ.
5. V-shaped sulcus. Epithelium in front from ectoderm, behind from endoderm.
6. Foramen cæcum.
7, 8. Base of tongue.
9. Epiglottis.

(*After Fischel.*)

(*From "Diseases of the Tongue," Spencer and Cade, H. K. Lewis,* 1931.)

between the first and second branchial arches in the third week. With the increase in length of the neck the thyroid tubercle elongates, and below the level of the hyoid bone it forms the pyramidal lobe, the isthmus and the greater part of the lateral lobes of the thyroid gland. Normally the thyroid tissue above the pyramidal lobe disappears; if it persists it gives rise to abnormalities such as a thyroglossal cyst or a lingual thyroid.

ANATOMY

It is of clinical interest and of practical importance in the consideration of surgical diseases of the tongue to sub-divide the organ into various anatomical sections. The tongue consists of the following parts: (1) the *body* of the tongue, forming the main mass of the organ, and made up of bundles of muscular fibres; (2) the *dorsum*, which faces the palate and pharynx; (3) the *base* of the tongue, that portion which is attached to the hyoid bone; (4) the *apex*, or tip, the free anterior extremity; (5) the *lateral margins*, or borders from the tip to the anterior pillars of the fauces; and (6) the *inferior* part, facing the floor of the mouth. The *dorsum* of the tongue embryologically, in structure and in function, can be sub-divided into two parts: (*a*) the *anterior* or *oral* part which extends from the tip to the V of the circumvallate papillæ, and (*b*) the *posterior* or *pharyngeal* part comprising about one-third of the tongue, which faces the pharynx and the epiglottis and includes a recess, the *vallecula*, sub-divided into right and left by the central glosso-epiglottidean fold and the two lateral pharyngo-epiglottidean folds.

Musculature.

The main mass of the tongue is composed of *intrinsic* muscles; these are arranged in three directions: longitudinal, vertical, and transverse. The *extrinsic* muscles of the tongue are four in number: (1) genio-glossus; (2) hyo-glossus; (3) stylo-glossus; and (4) glosso-palatinus. The extrinsic muscles together with the mylo-hyoid and digastric form the floor of the mouth. The nerve supply to the lingual muscles is derived from the hypoglossal nerve, with the exception of the palato-glossus which is supplied by the spinal accessory nerve through the pharyngeal plexus.

Epithelial covering.

The differentiation of the tongue into two portions, *anterior* and *posterior*, which has been already referred to on embryological grounds, is further maintained by the difference in the epithelial covering. The *anterior part* of the dorsum of the tongue is covered with mucous membrane of a specialised epithelial character: it is thick and stratified and covered by numerous papillæ not unlike those of the skin. There are three varieties of specialised lingual papillæ: (1) *Circumvallate* papillæ which form a V-shaped row at the junction of the anterior and posterior parts of the tongue; the apex of the V is at the foramen cæcum (fig. 2712). They consist of about a dozen large circular plateaux, surrounded by

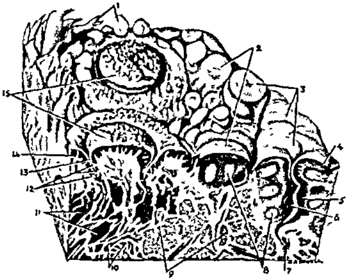

Fig. 2712.—EPITHELIAL SURFACE. BASE OF THE TONGUE.

1. Conical and filiform papillæ.
2. *Lymphoid nodules.*
3. Lymph follicles
4. Epithelium covering lymph follicle.
5. Leucocytes wandering through the epithelium.
6. Crypt between lymph follicles
7. Mucous gland duct opening into crypt.
8. Medullary germinating interior of lymph follicle.
9. Mucous glands.
10. Muscle
11. Serous glands.
12. Taste buds.
13. Fossa around circumvallate papilla
14. Vallum or ring
15. Circumvallate papillæ.

(*Magnified sixteen times, from Braus,* Anatomie, 1924, *through Sicher.*)
(*From "Diseases of the Tongue," Spencer and Cade, H. K. Lewis,* 1931.)

a narrow groove; at the periphery of the vallum the mucous membrane is raised. In the epithelium covering the sides of the vallum and the sides of the vallate papillæ are embedded taste-buds which receive the terminal filaments of the glosso-pharyngeal nerve. (2) Conical papillæ often fringed with epithelial filaments, and hence known as the *filiform* papillæ, cover the rest of the anterior part of the dorsum of the tongue (fig. 2713). (3) Amongst the filiform papillæ are scattered larger vascular papillæ, the *fungiform* papillæ. A few serous glands are found amongst the papillæ. The *posterior* part of the tongue, behind the V, is covered by stratified epithelium which is devoid of papillæ but covered by numerous lymphoid nodules forming small nodular masses known as the *lingual tonsils*;

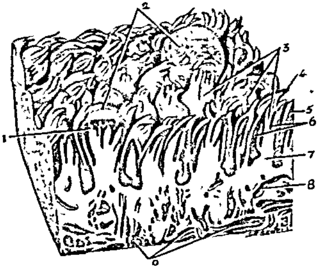

Fig 2713.—Epithelial surface of the tongue.

1. Taste goblet.
2. Fungiform papillæ.
3. Filiform papillæ.
4. Keratinised horny tip of papilla.
5. Deep layers of squamous epithelium.
6. Dermis framework of papillæ.
7. Connective tissue stem of papilla.
8. Blood vessel.
9. Muscle.

(*Magnified sixteen times, from Braus, Anatomie, 1924, through Sicher*)
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these nodules contain lymph follicles. The lateral margins of the tongue are covered with papillæ similar to those found on the dorsum. At the posterior ends of the lateral borders, in front of the anterior pillar of the fauces, are found a group of large nodules known as the *foliate* papillæ. They are part of the normal gustatory apparatus. They are covered with mucous membrane, vary in size and in the number of lobulations, and extend over an area of about one square centimetre. Their normal appearance varies from a slight elevation to a definite aggregation of four or more nodes separated by vertical folds of mucous membrane. Histological sections reveal the usual coverings of stratified epithelium, the presence of taste goblets and, in some cases, lymphoid follicles. In the majority of people the presence of well-developed papillæ is ignored, but occasionally either the patient or his medical attendant becomes aware of their existence from a casual inspection

of the mouth or from slight discomfort due to inflammation. At times the hypertrophy of the papillæ gives rise to a suspicion of the presence of an early neoplasm. As a matter of fact, there is no special predisposition to malignant hyperplasia in the foliate papillæ. Hypertrophy is either *congenital* in origin, when the gustatory apparatus is over-developed, or *inflammatory*, when the lymphoid tissue, which is part of the normal structure, is affected. It is chiefly the latter type which causes the patient to seek advice. The clinical history of such cases is that following an attack of tonsillitis or pharyngitis discomfort is noticed in the lateral aspects of the tongue ; it never amounts to actual pain and the symptoms are slight. It occurs in both sexes, in middle-aged people, and on examination it is found that the papillæ are somewhat œdematous and the mucous membrane may be reddened. The importance of this condition is the differential diagnosis. The characteristic site, the extent of the papillæ, and the facts that they are bilateral, that the mucosa is intact, and that no induration is

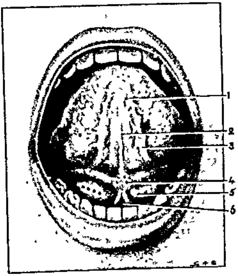


Fig. 2714.—Orifices of Salivary Ducts and Under-surface of the Tongue.

1. Blandin gland duct orifice.
2. Raphe of tongue.
3. Plica fimbriata lingualis.
4. Submaxillary gland. Wharton's duct orifice on papilla at anterior end of plica fimbriata sublingualis.
5. Sublingual gland duct orifice.
6. Frenum.

(*From "Diseases of the Tongue," Spencer and Cade, H. K. Lewis*, 1931.)

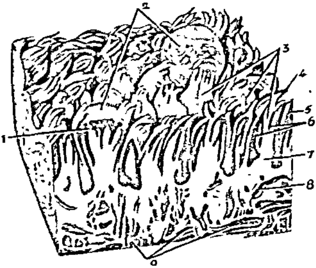
felt on palpation should be sufficient to show the true nature of the condition. Treatment should be confined to a mild mouth-wash or to one or two local applications of tincture of iodine.

The rest of the mouth—cheeks, gums and palate—is lined with stratified epithelium containing microscopic vascular papillæ. The connective tissue corium contains large numbers of small secretory glands ; the majority of these are *mucous glands*, but here and there scattered in the mucosa of the palate and cheeks are glands of *mixed* type similar to the salivary glands. These are the origin of the mixed mucous and salivary tumours which are from time to time found in the palate, lips and cheek, either along with or in conjunction with parotid or submaxillary mixed tumours.

The Inferior Surface of the Tongue and Floor of the Mouth.

The under-surface of the tongue is devoid of papillæ and is covered by a smooth shining mucous membrane (fig. 2714). A fold of the mucosa runs centrally from the under-surface down to the floor of the mouth, and from there to the inner aspect of the mandible ; this is the *frenum*. On each side of the frenum are the openings of Wharton's duct. The ducts of the sublingual glands open along the floor of the mouth on each side. Two fringed folds of mucous membrane are

a narrow groove; at the periphery of the vallum the mucous membrane is raised. In the epithelium covering the sides of the vallum and the sides of the vallate papillæ are embedded taste-buds which receive the terminal filaments of the glosso-pharyngeal nerve. (2) Conical papillæ often fringed with epithelial filaments, and hence known as the *filiform* papillæ, cover the rest of the anterior part of the dorsum of the tongue (fig. 2713). (3) Amongst the filiform papillæ are scattered larger vascular papillæ, the *fungiform* papillæ. A few serous glands are found amongst the papillæ. The *posterior* part of the tongue, behind the V, is covered by stratified epithelium which is devoid of papillæ but covered by numerous lymphoid nodules forming small nodular masses known as the lingual tonsils;



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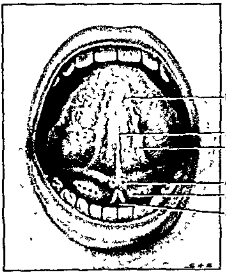

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situated on each side of the median raphe on the under-surface of the tongue; these are the *plicæ fimbriatæ*. Embedded in the under-surface of the tongue, posterior to the apex, and on each side of the middle line is a series of mixed serous and mucous glands opening by numerous ducts; these are the glands of Blandin and Nuhn.

Vascular Supply of the Tongue.

The lingual is the main artery of the tongue. It arises from the external carotid artery in the angle formed by the posterior belly of the digastric and the edge of the sterno-mastoid muscles. It passes forward deep to the hyo-glossus muscle and sub-divides into the sublingual, the ranine, the dorsalis linguæ, and the artery to the sublingual gland. There is practically no anastomotic vessel between the two sides. The lingual artery may be *ligatured at its junction* with the external carotid (fig. 2715). It is exposed to view by dividing the skin, subcutaneous structures and deep fascia, and retracting the sterno-mastoid backwards and the posterior belly of the digastric forwards and upwards; the vessel lies behind the tip of the

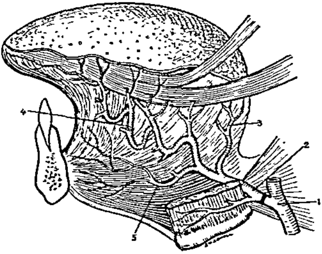

Fig 2715.—ARTERIAL SUPPLY TO THE TONGUE.

1. External carotid artery.
2. Lingual artery.
3. Dorsalis linguæ branch.
4. Sublingual artery
5. Ranine artery.

The site of election for ligature of the lingual artery to control hæmorrhage of the tongue is indicated.

great cornu of the hyoid bone. Ligation of the lingual at the edge of the sterno-mastoid is preferable to ligation in the digastric triangle, as the latter does not always secure the vessel proximal to the origin of the dorsalis linguæ branch. The blood supply to the gums, the teeth, and the buccal mucosa and palate is derived from the internal maxillary artery. It can be controlled by ligaturing the external carotid. The venous return from the tongue and mouth runs to the sub-maxillary region and the anterior triangle of the neck between the superficial and deep fascia or beneath the deep fascia. The vessels begin as venæ comites and are sub-divided into three main groups: tributaries to the internal jugular, the external jugular, and the anterior jugular veins. The anterior facial vein receives blood from the face, lips and chin, and lies in the proximity of the facial artery near the free border of the mandible; between the layers of the fascia covering the submaxillary gland it joins tributaries of the anterior and the external *jugular veins. The main venous return* from the tongue is provided by the ranine veins, which join the lingual veins and the dorsalis linguæ vein and form a common trunk which opens into the internal jugular.

Nerve Supply to the Mouth and Tongue

Special Sense-Taste.

The gustatory organs are the *taste goblets;* they are epithelial organs placed between the basement membrane and the squamous surface layers. They are found here and there in the general mucous membrane of the tongue, but more frequently at the sides (near the papillæ foliatæ), at the back (near the circumvallate V), and upon the buccal surface of the soft palate and the epiglottis. They are flask-shaped, with a short neck which opens at the outer gustatory pore. The middle of the goblet is occupied by long spindle-shaped epithelial cells with deeply-staining nuclei of granular protoplasm; these *gustatory cells* are prolonged into a rod, the tip of which enters the inner gustatory pore. Sustentacular cells are placed around the gustatory cells. The base of the taste goblet receives a branch of the *glosso-pharyngeal nerve.* The afferent nerves of taste penetrate the goblets and end in apposition with the gustatory cells Division of the afferent nerves results in the degeneration of the goblet cells and their replacement by squamous epithelium. From the *anterior two-thirds* of the tongue the afferent nerves of taste pass up the chorda tympani with the lingual nerve to the stylo-mastoid foramen. Higher up in the aqueductus Fallopii the chorda tympani runs with the facial nerve; at the geniculate ganglion the afferent taste fibres take two courses to reach the glosso-pharyngeal nucleus: Most fibres pass up in the nervus intermedius to the dorsal nucleus of the facial; the remainder pass at the geniculate ganglion into the superficial petrosal nerve, thence to Meckel's ganglion, and by the second root of the fifth nerve and its main root to the dorsal nucleus of the facial. From the *posterior* part of the tongue and from the soft palate the afferent nerves of taste go with the *glosso pharyngeal.* From the *epiglottis* the taste fibres pass through the superior laryngeal branches of the vagus, which include fibres running into the glosso-pharyngeal root.

Sensory Nerves.

The common sensations of touch, pressure, temperature and pain in the *anterior* two-thirds of the tongue, the buccal mucosa, the palate and the lips are supplied by the *maxillary* and *mandibular* divisions of the fifth nerve. Common sensation and pain can be temporarily abolished by division of the lingual nerve. It can be anæsthetised by injection of alcohol or novocaine between the mucous membrane of the cheek and the internal pterygoid muscle, where it runs with the inferior dental nerve. The *glosso-pharyngeal* nerve is the afferent nerve of common sensation, touch, temperature and pain, and also of taste, in the posterior third of the tongue, the soft palate, the uvula, and the pillars of the fauces. Referred pain in the ear from lesions in these situations is transmitted by the tympanic nerve of Jacobson.

Motor Nerves.

The motor supply of the tongue is through the hypoglossal nerve. The nerve includes afferent fibres—proprioceptive—transmitting impulses relating to position from the muscles of the tongue. In the neck the nerve is joined by autonomic efferent nerves—vasoconstrictors to arterioles. The main trunk of the hypoglossal nerve hooks round the occipital artery, passes under the stylo-hyoid and the posterior belly of the digastric, crosses the digastric triangle, and sub-divides to supply the several muscles of the tongue where it terminates. The descendens

hypoglossi forms with anastomosing branches of the second and third cervical nerves the ansa hypoglossi which supplies the motor fibres to the depressors of the hyoid. The genio-hyo-glossi muscles move the tongue forwards and downwards, the hyo-glossi backwards and upwards; the stylo-glossi lift the base of the tongue upwards and backwards. Of the intrinsic muscles, the longitudinales shorten the tongue, pulling it up or down; the transverse muscles narrow the tongue; the vertical muscles flatten the tongue out. When the mandible is fixed, the genio-hyo-glossi and the hyo-glossi raise the hyoid bone. Division of the hypoglossal nerve produces paralysis of one half of the tongue, followed by hemiatrophy; deviation of the tip of the tongue to the paralysed side accompanies any attempt to protrude the tongue; at rest the tongue is drawn over to the sound side; the paralysed side is smaller and crinkled, and shows fibrillary movements: speech is affected, and the patient has the sensation of a foreign body in the mouth. Sense of touch or taste is not affected. Afferent fibres are present in the hypoglossal nerve. They are believed to have the proprioceptive function relating to position.

Lymphatic Supply of the Mouth and Tongue

The lymphatic drainage of the tongue and mouth consists of: (1) Lymph nodes situated in a circular fashion at the posterior part of the mouth; (2) the lymphatic vessels originating in the mucosa of the cheeks, palate, gums, floor of mouth, and tongue; and (3) the cervical lymphatic glands.

(1) The *lymph nodes* form a ring consisting of the faucial tonsil, the pharyngeal tonsil and the lingual tonsil: the latter is spread over a wide area of the base of the tongue between the epiglottis and the circumvallate papillæ and outwards towards the foliate papillæ. The presence of the lymphoid tissue is of importance

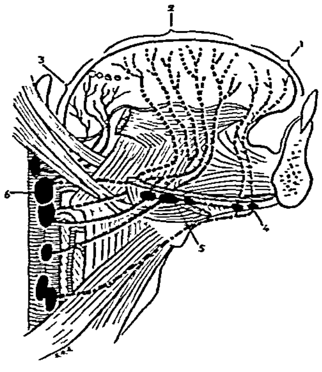

Fig. [illegible]16.—Lymphatic drainage of the tongue.

1. Anterior group.
2. Middle group.
3. Posterior group.
4. Submental glands.
5. Submaxillary glands.
6. Upper deep cervical glands.

(Cf. with *Fig.* [illegible].)

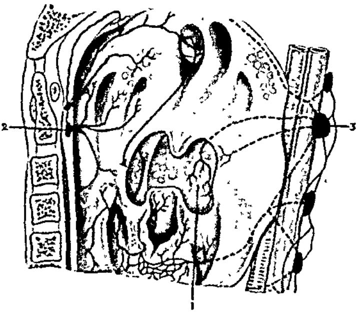

Fig. 2717.—VALLECULA, EPIGLOTTIS AND NASO-PHARYNX AS SEEN FROM BEHIND.

1. Drainage of vallecula.
2. *Retro-pharyngeal gland.*
3. Upper deep cervical glands.

(*After Torrigiani e. Palumbo.*)

in the interpretation of the histological appearances of malignant growths in that area, and their differentiation, even microscopically, into carcinoma and sarcoma is sometimes very difficult. *The lymphatic follicles in the posterior part of the* mouth are radio-sensitive, as are also the tumours which arise in them. They are very frequently the seat of lesions in lymphatic leukæmia.

(2) The *lymphatic vessels* (fig. 2716). In the tongue there are *three* groups of lymph-vessels: (*a*) anterior; (*b*) middle; and (*c*) posterior. There is a free communication between the anterior and middle groups both with one another and with the opposite side; the posterior group is a separate entity. The *anterior*

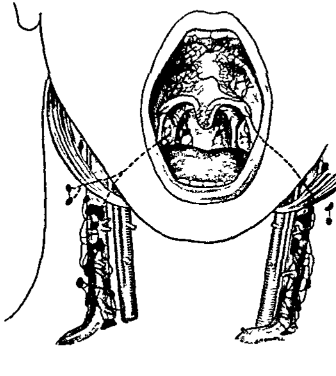

Fig. 2718.—DIAGRAM OF LYMPHATIC DRAINAGE OF PALATE, UVULA, TONSIL AND BACK OF TONGUE.

(*After Torrigiani e. Palumbo.*)

group drains the tip of the tongue and the inferior surface of the free portion. It also drains the upper and lower lip, the frenum, and the mucous membrane of the gums. These lymphatic vessels perforate the mylo-hyoid muscle and terminate in the submental lymphatic glands. The *middle group of the lingual lymphatic vessels drains the anterior two-thirds of the tongue excluding the tip*; they end partly in the submaxillary glands and partly in the inner group of the upper deep cervical glands. The *posterior* group drains the pharyngeal portion of the tongue and passes to the upper deep cervical glands (see figs. 2716 and 2717). Most of the superficial and deep lymphatics of the *buccal mucosa* drain into the submaxillary

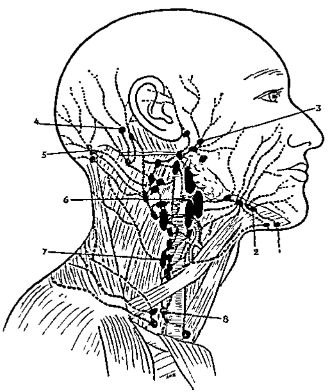

Fig. 2719.—Lymphatic glands draining the mouth and tongue.

1. Submental.
2. Submaxillary.
3. Parotid.
4. Retro auricular.
5. Occipital.
6. Upper deep cervical.
7. Lower deep cervical.
8. Supra-clavicular

(Cf. with *Fig* 2277.)

glands; some end directly in the deep cervical glands and some in the pre-auricular glands. The soft palate and uvula drain into the retro-pharyngeal glands as well as in the deep cervical glands (see fig. 2718).

(3) *Cervical lymphatic glands* (fig. 2719). The lymphatic glands draining the oral cavity and the tongue consist of the following groups: (*a*) *Submental lymphatic glands.* These lie on each side of the middle line below the chin, deep to the platysma, on the mylo-hyoid muscles, between the anterior bellies of the two digastrics. Efferent vessels drain into the submaxillary, the upper and the lower deep cervical glands. (*b*) *The submaxillary lymphatic glands.* These lie deep to the deep fascia in intimate relation to and within the capsule of the submaxillary salivary glands. A gland belonging to this group is also found on the facial vessels where these become superficial. (*c*) *The deep cervical glands* (see also page 4124). These form a chain along the vascular bundle of the neck; they lie in front of, behind, and underneath the sterno-mastoid muscle. Those in front of the

sterno-mastoid commence deep to the parotid gland; small glands are also found deep to the capsule of the parotid. *The glands extend along the* carotid sheath, along the posterior belly of the digastric, and deep to it; they can be distinguished as two chains, an inner and an outer, and form the upper deep cervical glands; *they vary in size, but a big gland is nearly always* present at the level of the bifurcation of the carotid. The intimate relation to the internal jugular vein and the sterno-mastoid muscle makes it imperative *to remove these two structures if an adequate clearance of the cervical lymphatics* is to be achieved. Immediately above the omo-hyoid is a large lymphatic gland closely connected with the internal jugular vein; this gland receives efferent lymphatics from the submental glands. *The lower deep cervical glands* are the continuation of the upper group and anatomically are separated from it by the omo-hyoid muscle; these glands are situated at the junction of the anterior and external jugular veins with the internal jugular.

CHAPTER II

Examination of the Mouth and Tongue

The examination of the mouth and tongue should be undertaken on definite lines so that no important data may be omitted. A good artificial light is essential. A head-mirror or a small electric pencil-light must be available. Laryngeal mirrors of suitable size, spatulæ, linen squares, a spirit lamp, and a 15 per cent solution of cocaine in a spray are required.

The history of the case is obtained Important points to note are: duration of symptoms, mode of onset, initial symptom, rate of progress of the disease, the presence or absence of pain. salivation. bleeding, difficulty in swallowing or breathing, cough, and alteration in sense of taste. An enquiry should be made as to a past history of syphilis, excessive smoking, or undue indulgence in alcohol.

Inspection of the Mouth.

A careful examination of the patient's mouth is made. At first a general view of the mouth and teeth is obtained. If artificial teeth are worn by the patient they should be inspected *in situ* and a note made of a roughness of the plate, or of pressure of the dentures on the gums or tongue. The plates are then removed and examined The mouth is inspected; the floor of the mouth, the roof, and the buccal mucosa are scrutinised; the outer and inner aspects of the gums and teeth are examined; mobility of the tongue is tested; the dorsum of the tongue is dried with a square of gauze and the papillæ are inspected. The tongue is next depressed with a spatula and the tonsils, pillars of the fauces, uvula, palate, and posterior pharyngeal wall are passed in review. With the aid of a mirror the posterior part of the tongue. vallecula, epiglottis, larynx and pyriform fossæ are examined. If mucus, pus. saliva or blood obscures the view, the patient is asked to rinse his mouth, clear his throat, and swallow some water, after which the examination is repeated. If the examination is difficult owing to the presence of a painful lesion, the mouth and throat should be sprayed with a 15 per cent solution of cocaine and any painful fissure or other lesion should be dabbed with a pledget of cotton wool dipped in the cocaine solution. This will render a thorough examination possible in most cases.

Palpation of the Mouth

With a gloved finger the tongue and buccal mucous membrane should be palpated, special attention is paid to the consistency of the tongue, and any induration in the substance of the tongue, the cheeks or the floor of the mouth is noted. Bimanual palpation of the floor of the mouth gives useful information. No examination of the mouth is complete without a careful palpation of the neck. This is carried out systematically, the anterior, posterior and submaxillary triangles being felt. as well as the supraclavicular fossæ. Special attention is paid to the submental area, where small enlarged glands are easily missed. The two sides of the neck are compared and any abnormality noticed. If enlarged glands are present, their distribution, size, consistency, and mobility or fixation are noted.

Radiological Examination.

Skiagrams of the lower jaw and teeth should be taken if there is any doubt as to the diagnosis or the condition of the jaw. A skiagram of the epiglottis, vallecula and tongue in an antero-lateral view with air in the pharynx gives additional help as to the configuration, size, and position of the back of the tongue.

A general examination of the patient should never be omitted, as cases where the disease of the mouth is only a local manifestation of generalised disease will thus not so frequently be missed. The cardio-vascular system, the abdomen with special reference to any enlargement of the spleen or liver, and examination of the urine, sometimes throw a great deal of light on some obscure condition of the mouth and pharynx. The usefulness of a Wassermann or Kahn test, of a blood count, and of suitable bacteriological examination must be kept in mind. Finally, recourse to a biopsy should be seriously considered in all lesions where the diagnosis is doubtful. It should be employed frequently and will give information as to the true nature of the pathological condition in most if not in all cases.

CHAPTER III

Malignant Disease of the Mouth and Tongue

SARCOMA

Sarcoma of the tongue or buccal mucosa is rare; only a few undoubted cases can be said to have been recorded. In the mouth it occurs in the tissues of the cheek, lips, palate or tongue. Histologically, it is difficult to distinguish from lympho-epithelioma but true cases of lympho-sarcoma occur in the vallecula and in the lymphoid tissue at the back of the pharynx; in the tonsil they are met with much more frequently. The progress of the disease is rapid, and glandular dissemination occurs early, is widespread, and recurs rapidly after surgical excision. In most cases the tumour in the tongue has an ill-defined capsule. The degree of malignancy varies with the histological structure. The spindle-celled variety is less virulent than the round-celled, and in some cases pursues the slow course typical of fibrosarcomata. I have treated a schoolgirl of thirteen years of age with a round-celled sarcoma of the buccal mucosa; there were secondary deposits in both lungs and in the liver within eight months from the onset of the disease.

CARCINOMA

The common variety of malignant tumour in the mouth and tongue is the epidermoid carcinoma or squamous-celled variety.

Ætiology

Age incidence. The largest proportion of cases of cancer of the buccal cavity and tongue occur in the sixth decade. The following table gives the figures relating to the deaths at different ages in England and Wales:

Age in Years.	Male.	Female.
0–10	3	2
10–20	2	9
20–30	4	2
30–40	20	11
40–50	161	55
50–60	720	100
60–70	1072	106
70–80	667	105
80–	141	32

Children and young adults are very rarely affected, but authenticated cases have been described both in a newly-born infant and in very young patients.

Sex incidence. In England and Wales the average percentage of women dying of buccal cancer is 15. It is well known that the disease is much more common in men in most countries; recent observations in Sweden, however, show that the proportion of females in that country is 40 per cent; the importance of this increase of incidence is its ætiological significance and it deserves further study. The sex incidence is greater between the fourth and sixth decades.

Social incidence. Cancer of the mouth and tongue is found much more frequently in the poorer classes. The distinct thesis that oral sepsis is a predisposing cause of cancer is supported by hospital experience, the majority of patients with carcinoma of the mouth having foul teeth which have been neglected for many years. Oral sepsis, and the concomitant toxæmia and anæmia, may be to a certain extent responsible for the development of the disease.

Predisposing causes. The term "pre-cancerous" was applied by Hutchinson in 1872 to various manifestations of buccal syphilis. Clinical observation supports the existence of a "predisposing" factor to the extent that most tumours arise in tissues which have been altered by previous chronic inflammatory processes and chronic irritation sometimes preceding the development of the tumour by fifteen to thirty years. All the predisposing factors can be summarised as long-continued irritation of the mucous membrane of the tongue and mouth; of these *syphilis*, *tobacco*, *defective teeth* and the continued heavy consumption of *spirits* are the most common. The incidence of *syphilis* is variously recorded by some as low as 3 per cent, and by others as high as 75 per cent. The action of syphilis is indirect; there is no direct irritation by the spirochætal infection, but the ulceration, scarring and leukoplakia are a definite predisposing factor. All syphilitic lesions, epithelial hypertrophies, cracks and fissures, gummata, chronic glossitis, atrophy of the mucosa with scarring and localised warts must be considered as well as leukoplakia to be predisposing conditions. Experimentally, Fibiger produced carcinoma of the rat's tongue by the artificial production of leukoplakia by an animal parasite (*spirochæta neoplastica*). The effect of *tobacco* is sometimes an important factor, such as the occurrence of epithelioma in "*smokers' patches.*" But the action of the tobacco is still not perfectly understood. Laborious experiments by the late Professor A. Leitch showed that tobacco *by itself* was not a

specific irritant and was not a proved carcinogenic substance; but there may be something connected with tobacco-smoking which in the human mouth favours the predisposition to cancer; thus the irritating effects may stimulate the epithelial covering of the mouth by producing chronic hyperæmia and so favouring erosions, superficial ulcerations and lymphocytic infiltration. It is also possible that the lesions are not due to the tobacco itself but to the heat of the smoke, although the occurrence of cancer of the cheek in those addicted to tobacco chewing indicates a direct effect. The predisposing factor of *defective teeth* is twofold; the obvious relation between the abrasions and ulceration caused by a ragged or sharp tooth indicates a direct effect between a traumatic ulcer and its subsequent metaplasia into a neoplasm. The presence of grossly infected teeth, thickly covered by a coating of hard debris without any evidence of a direct injury, is so often found in cases of cancer of the mouth that some causative relationship seems inevitable. The ætiological significance of a dirty mouth is perhaps not very great, as a number of tongue cancers occur in edentulous patients, but the importance of a clean mouth as a prophylactic measure cannot be sufficiently emphasised. The local application of *chemical irritants*, such as silver nitrate, has been the cause of many cases of cancer of the tongue. As long as fifty years ago Butlin pointed out: "If there be one thing more harmful than another in the treatment of simple indolent sores and affections of the tongue in persons over thirty years of age, it is the application of strong caustic." Repeated applications of silver nitrate to an otherwise benign lesion of the buccal mucosa and tongue will lead within a few months to the development of an epithelioma The pre-cancerous conditions which frequently precede the appearance of cancer in the mouth have been enumerated by Jacobson as follows: (1) Chronic superficial glossitis with hypertrophy and fissuring; (2) leukoplakia, especially with the appearance of warts: (3) ichthyosis or late stage of leukoplakia; (4) chronic atrophic glossitis; (5) papillomata; (6) fissures; and (7) ulcers of any type. These conditions, however, do not account for the development of malignant disease in the posterior part of the tongue. The predisposing factors occur in the anterior part only and lead to the squamous-celled carcinoma of the epidermoid type. The occurrence of malignant lesions in the pharyngeal portion of the tongue, their embryonal type and their distribution in areas which are rich in lymphoid tissue, all point to a different ætiological factor such as tissue predisposition or some structural abnormality.

Histology of Cancer of Mouth and Tongue

The majority of cases of buccal and lingual cancer are squamous-celled carcinomata or epitheliomata. They develop from the stratified epithelium of the surface of the mouth. Glandular carcinoma originates occasionally in the mucous glands on the floor, and very exceptionally from those on the surface of the tongue; these are not true lingual cancers. The histological appearance of the common variety can be sub-divided into two groups:

(1) *Squamous-celled carcinoma with cell nests* (fig. 2720). This occurs in all parts of the mouth but much more commonly in the anterior two-thirds of the tongue. In the earliest stages can be seen some of the phases of the development of simple acanthoma from chronic inflammation and hypertrophy of the papillæ. The actual downgrowth of epithelial columns is preceded by hyperkeratosis,

Fig 2720.—Section showing squamous-celled carcinoma with cell-nests.

submucous œdema, and round-celled infiltration. The adult type of epithelium may persist or a transformation into undifferentiated polyhedral cells occur. Columns of epithelial cells, not unlike those of the deeper layers of the epidermis and directly continuous with them, grow down into the fibrous tissue and through it into the muscles; as a rule, these columns diverge, branch, anastomose with one another and form networks in the deeper strata of the tongue. The slender processes which form these networks are composed of altered epithelial cells; they are easily recognised as epithelial in origin, but they differ in many important respects from the cells which form the normal epithelial covering of the tongue. They vary considerably in size, and are somewhat smaller than the cells of the more superficial layers of the epidermis. They vary as much in shape, but are seldom distinctly spindle or caudate; polygonal cells are common, not unlike those of tubular epithelioma. Many cells are frayed out at the borders; most

of them have nuclei which are very large in proportion to the size of the cells: as elsewhere, multinucleated cells occur. Amongst the larger columns are seen "epithelial pearls" or "cell-nests"; these are rounded or oval bodies consisting of altered central cells surrounded by layers of flattened scab-like cells arranged like the scales of a tulip. The degree of keratinisation is an index to the degree of malignancy, at least as far as radio-sensitivity is concerned, this type being less virulent than the non-keratinising variety; but it is not less erroneous to consider them otherwise than metastasising malignant tumours. The *stroma* around the malignant cells is infiltrated with small round cells; these are due to active proliferation of round connective tissue cells and are regarded as a protective mechanism which attempts to limit the spread of the disease. The hardness of the lesion is due to this *infiltration with small round cells*.

(2) *Squamous-celled carcinoma without cell-nests.* This is a rarer type of epithelioma of the tongue. The importance of recognising

Fig. 2721.—Section showing lympho-epithelioma.

this group was emphasised by the development of radiation therapy. These tumours are highly malignant and metastasise early and widely; they are extremely sensitive to radiation: they occur in the base of the tongue, naso-pharynx, tonsil, and sometimes in other parts of the body. This type of tumour is sub-divided into two groups: (*a*) *The lympho-epithelioma* (fig. 2721), first described by Régaud: and (*b*) *the transitional-celled carcinoma* (fig. 2722), or anaplastic carcinoma, described by Quick and Cutler. The histological appearance of the lympho-epithelioma is that of large cells with a delicate cell membrane and trabeculated protoplasm with large nuclei: they do not form cell-nests: the cells are round or spheroidal; they are at times very difficult to distinguish from round-celled sarcoma. In a review of 300 tumours of the base of the tongue and naso-pharynx Ewing found 6·3 per cent of cases of this type. The transitional-celled carcinoma

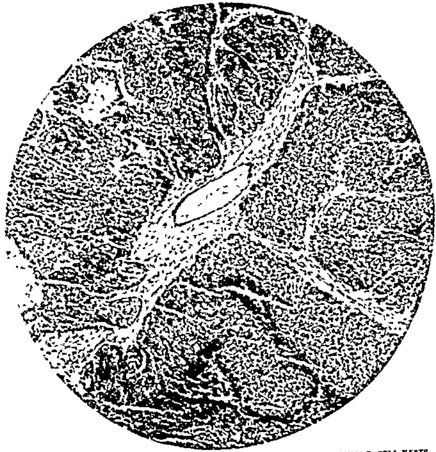

Fig 2722.—Section showing transitional-celled carcinoma without cell-nests.

consists of round and polyhedral cells with large nuclei and little intercellular material; there are no squamous characters and a marked degree of anaplasia. Cutler believes that these two groups have a different origin. Whereas the lympho-epithelioma is thought to arise from squamous epithelial cells in close contact with and infiltrated by lymphoid tissue, the transitional-celled carcinoma is probably a manifestation of anaplasia. These tumours are highly radio-sensitive and it is this property that first attracts attention to their unusual histological appearance.

Clinical Types of Cancer of the Mouth and Tongue

The disease may assume a variety of aspects which depend primarily on the virulence of the disease, secondly on the condition of the stroma and the particular predisposing cause, and thirdly on the relative vascular and lymphatic supply of the part where the neoplasm arises. There is clinical evidence that the various pre-cancerous conditions—excoriations, traumatic ulcers, syphilitic changes, benign tumours—develop into different types of carcinoma. The following types are recognised :

(1) *Ulcerative type.* This is the commonest variety (fig. 2723). The appearances of the ulcer depend upon the rate of growth, the presence of sepsis, and the pre-existing state of the tongue. Induration of the ulcer, and hardness of the edge and base are characteristic. Most carcinomatous ulcers are oval in shape; at first they are relatively painless, but with supervening infection pain increases.

(2) *Fissured type.* This variety occurs in the clefts and depressions resulting from old-standing glossitis of syphilitic origin. The ulcer is deep-seated and the fissure is the superficial portion of the neoplasm; deep to the fissure a hard mass can usually be felt. The lesion is more extensive than the superficial appearance indicates.

(3) *Nodular type.* This appears first as a plaque or node (fig. 2724), submucous in position, and covered by smooth and intact epithelium devoid of papillæ. It may be a broad plaque, slightly raised above the surface, or retracted from it, forming a deep-seated stony hard nodule. This type is slow in progress and does not ulcerate till late; it may invade the tongue widely and present on the surface at a point well removed from its original site; necrosis due to lack of blood supply generally leads to ulceration. It remains painless for a long time and therefore histories of one or two years are not infrequent.

(4) *Papillary type.* This varies in size and in appearance from a small soft wart to extensive papillary masses filling the mouth (fig. 2725). It occurs in apparently normal mouths as well as engrafted on old-standing glossitic lesions. In early cases the lesion is circumscribed, soft except at its base, and sometimes pedunculated. Multiple warty lesions are not infrequent; they may be situated side by side or in apposition (lips, cheek and tongue) with but little intervening normal tissue, or they may be truly multicentric in origin and occur on opposite sides of the mouth. The cauliflower type belongs to the papillary group. in such cases there may be extensive fungating masses of new growth with a hard infiltrating base (fig. 2726). Bleeding occurs even in the absence of gross ulceration, infection is common, and the growth becomes friable.

(5) *Atrophic type.* This is the rarest variety of lingual cancer; it occurs in the buccal mucosa as well as in the tongue; it is similar to the atrophic type of scirrhus seen in the breast. Ulceration is slight and superficial (see fig. 2727), but there is intense fibrosis which by contraction gradually shrinks the tongue to a small hard mass.

Multiplicity of Lesions.

Two or more distinct epitheliomata may develop simultaneously in the tongue, cheeks, pillars of the fauces and palate. A number of such

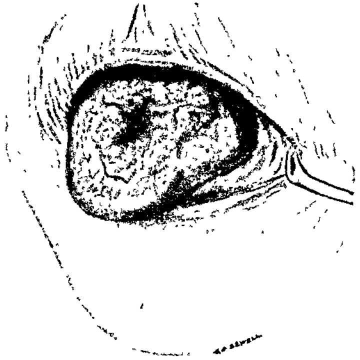

Fig. 2723 —CARCINOMA OF TONGUE, ULCERATIVE VARIETY

Fig 2724.—CARCINOMA OF TONGUE, NODULAR VARIETY—EARLY CASE.
(*Museum, Westminster Hospital*)

Fig 2725 —CARCINOMA OF TONGUE, PAPILLARY TYPE—EARLY CASE. PAPILLOMA SHOWING EARLY SIGNS OF CHANGE TO EPITHELIOMA AND COMPOSED OF ELONGATED AND BRANCHED PAPILLÆ COVERED BY THICKENED EPITHELIUM. THE EPITHELIUM IS LIKEWISE THICKENED AROUND THE PEDICLE. THE STEM IS FORMED OF DENSE FIBROUS TISSUE.
(*Mr W G. Spencer's case*)

Fig. 2726 —CARCINOMA OF TONGUE, CAULIFLOWER TYPE—MODERATELY ADVANCED
(*Museum, Westminster Hospital*)

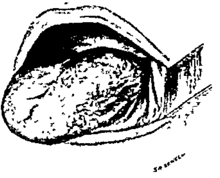

Fig 2727.—CARCINOMA OF TONGUE, INFILTRATING TYPE. THERE IS ONLY SLIGHT ULCERATION.

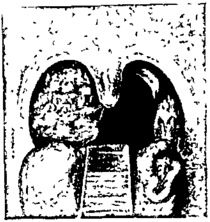

Fig 2728.—MULTIPLE LESIONS IN THE MOUTH APPEARING SIMULTANEOUSLY, SHOWING BOTH LESIONS—ONE CAULIFLOWER IN TYPE AND THE OTHER ULCERATIVE—ON OPPOSITE SIDES OF THE MOUTH.

cases have been recorded (fig. 2728). The lesions are not always of the same gross anatomical variety; one lesion may be ulcerative, and the other papilliferous. Multiplicity of lesions is of grave prognostic significance, as there is a tendency to local recurrence or the development of fresh lesions.

Localisation of the Tumour.

The malignant growth in the mouth may occur in the following situations:

(1) *Roof of the mouth.* In this localisation a distinction should be made between lesions arising in the maxillary antrum and presenting in the mouth and the primary lesions of the palate. The latter can be usefully sub-divided into growths of the *hard* palate and those of the *soft* palate. This classification is of some prognostic significance as the former rarely give rise to glandular metastases till late in the disease, and these are generally unilateral, whilst the soft palate lesions are more malignant, metastasise early, and frequently give rise to bilateral cervical lymphatic involvement.

(2) *Buccal mucosa.* Epithelioma of the cheek attacks the buccal mucosa and spreads to the alveolar sulcus of the upper and lower jaws, and also to the gums. It pursues a course similar to that of cancer of the tongue and gives rise to metastasis early.

(3) *Floor of the mouth.* The lesion is situated either laterally or in the region of the frenum, and is nearly always ulcerative in type, although papilliferous growths are occasionally seen; the origin of such growth may be entirely independent of the tongue, although the latter is generally involved by direct extension if the disease progresses.

(4) *Tongue.* The commonest site in the tongue is the lateral margin, but no part of the tongue is immune. The average relative frequency of the site distribution of lingual cancer is as follows:

Anterior	50 per cent
Posterior	23 per cent
Inferior	25 per cent
The whole tongue	2 per cent

The lateral borders are affected twice as often as the central portion; in the posterior group one or both valleculæ can be affected and the disease spreads to the epiglottis and to the pillars of the fauces. It is also possible for a carcinoma of the pillars of the fauces or tonsil to spread to the tongue and floor of the mouth.

Extent of the Lesion.

The wide extension of the growth from one part of the mouth to another, and the possible multiplicity of lesions make a *careful* and *full* examination of the whole mouth and pharynx a point of very great practical importance. The size of the growth and its extensions are, as a rule, in direct proportion to the length of time the lesion has been present. The papillary and cauliflower lesions are the most rapid in their growth; the ulcerative variety is slower except in post-operative or post-radiation recurrences, when, owing to interference with the blood supply, necrosis is prone to occur and rapid extension of the ulceration takes place. In tongues which are the seat of chronic syphilitic glossitis, the whole organ may be involved from the tip to the circumvallate papillæ. On the floor of the mouth the ulcer may spread backwards and so separate half the tongue from its bed.

Symptoms

The symptoms of malignant disease of the mouth and tongue can be usefully sub-divided into two groups—early or initial, and late. The majority of patients seen in hospital fall into the latter group. The average time which elapses between the first symptom and the patient's appearance in a hospital out-patient department is about six months. The delay is sometimes due to palliative measures prescribed by the private practitioner, but mostly to indifference or fear on the part of the patient. Education both of the public and of the medical profession is necessary to make the patient report to hospital at an earlier stage. Most cases are beyond cure when first seen, and this may be the cause of the indifferent results obtained by any method of treatment and of the high mortality of the disease.

Fœtor of the breath is the usual accompaniment of lingual and buccal cancer; at times it is so marked that the patient has to be isolated. The sense of taste is lost, and toxæmia, anorexia, fever and anæmia follow.

Signs and Symptoms of Carcinoma of the Posterior Part of the Tongue

Growths in the posterior part of the tongue, vallecula and epiglottis are clinically silent for longer periods than lesions in the anterior half. It is, therefore, of very great importance to be familiar with the clinical picture of the early lesions in this situation. The symptoms are vague and slight, but quite characteristic to the observant medical man. There is usually a history of repeated transient attacks of sore throat, at first very slight, but later more constant and more persistent; slight dysphagia follows; occasional streaks of blood are noticed in the sputum; the voice is *slightly* altered and the *speech* somewhat thick and indistinct. Examination of the mouth may reveal nothing abnormal unless a laryngeal mirror is used. This should never be omitted, as growths in the vallecula, unless cauliflower in type, cannot otherwise be visualised.

Glandular Involvement.

Although there are great variations in the spread of the disease from its primary site to the lymphatic glands, both in its anatomical distribution and in the time when such spread occurs, the majority of cancers in the mouth and tongue (about 80 per cent) sooner or later

Fig 2729.—Section showing secondary deposit of squamous celled carcinoma in lymphatic gland. Primary growth in the tongue.

give rise to metastases *in the neck* (see fig. 2729). If the primary lesion remains untreated for a time, it inevitably extends to the lymphatic glands; such extension is earlier in onset, wider in distribution, and greater in degree than is obvious on clinical examination. From the study of glands removed at operations and from the observation of patients in whom the neck was *not* treated and malignant cervical glands developed after a complete eradication of the primary growth, it is clear that no case of cancer in the mouth can be said to be safe from lymphatic invasion at some date or other. The whole problem of oral cancer pivots on the potential malignancy of the cervical glands. Enlargement of the glands need not necessarily signify that dissemination has already occurred, as sepsis and infection produce *inflammatory* adenitis which may subside; on the other hand, neither does absence of palpable glands mean that dissemination has not yet occurred. The rapidity with which glandular involvement takes place varies from patient to patient; it depends upon the situation, extent and histological type of the primary growth; upon the presence and the degree of concomitant infection; upon the anatomical type of the lesion, and also on some undetermined susceptibility of patients to dissemination. It is frequently observed that whereas in some patients there is a period of many months or even one or two years between the appearance of the primary growth and that of the lymphatic deposits, in others both *seem to occur simultaneously*. At times the lymphatic glands are so large and the primary lesion so insignificant that the latter at first escapes detection and the glands are presumed to be the primary growth. The distribution of the lymphatic invasions depends to a certain degree on the situation of the primary growth. Cancer of the tip of the tongue infects the submental glands first; that of the floor of the mouth and of the central portion of the tongue, the submental, submaxillary, and carotid glands; that of the base of the tongue, the upper and lower deep cervical glands. This generalisation is, however, very imperfect. It is not one gland, not even a group of glands, which is affected, but the *chain* of deep cervical glands. As large efferent vessels run directly down to the glands at the *bifurcation of the carotid*, this group may be chiefly infected, as may be the glands at the level of the tendon of the omo-hyoid, but sooner or later the whole chain is affected from the mastoid down to the clavicle. The spread of the tumours from gland to gland occurs most probably by embolic steps. As a rule, early infection of lymphatic glands is unilateral when the primary lesion itself is strictly unilateral and limited; this does not apply to the soft palate or to the lympho-epitheliomata of the vallecula.

Not infrequently a growth which approaches the middle line may infect the glands on the *opposite side* to even greater extent than on the same side. Such anomalous contra-lateral metastasis may be the first to be noticed and can be explained by the reversal of lymph flow due to lymphatic obstruction. The decision as to treatment of the neck depends, therefore, on a very careful consideration of all the available data *in each particular patient: it must be based on sound knowledge of* the natural history of the tumour and its spread, on the clinical extent of the disease, and on the probable degree of infection by metastasis.

Dissemination (see also page 4172).

Before the advent of radiation therapy, visceral and cutaneous metastases were seen but infrequently in cases of cancer of the tongue

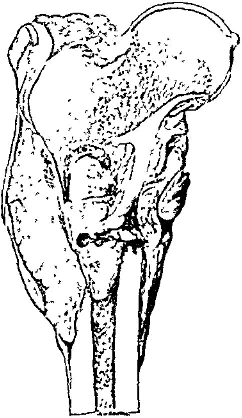

Fig 2730.—Secondary deposit of a squamous celled carcinoma in the femur. The primary growth was situated in the tongue.

(*Museum, Royal College of Surgeons*)

and mouth; they were reported as curiosities and were of greater interest to the morbid anatomist than to the clinician. Since the use of radium in the mouth has been widely practised, such metastases appear to be much more frequently noted, and it is asked, not unnaturally, whether radiation favours metastatic spread. Like most new methods of treatment, radiation cannot be exempt from suspicion of being the cause of such dissemination. A careful analysis of these cases shows: (1) That such metastases occur after long latent periods, sometimes

two or three years after treatment; (2) that they occur in patients where the primary growth remains healed and where the lymphatic glands in the neck have been successfully treated; and (3) that they occur in patients in whom the primary growth was originally advanced and extensive. Such cases, before the radium days, never lived long enough to develop visceral or skeletal metastases but died from sepsis, hæmorrhage or pneumonia. It seems to be a reasonable explanation that the prolongation of life and the palliation obtained enable the patient to complete the full cycle of the malignant process and that there is no direct evidence that radiation promotes visceral metastases. The recorded sites of distant metastases from the tongue and mouth are as follows: (1) *Bones.* Metastases have been seen in the cervical vertebræ, in the neck of the femur (see fig. 2730), and in the ribs.

(2) *Cutaneous* metastases have been seen on the chest wall, the abdomen and the back.

(3) *Visceral* metastases—in the lungs, the liver, the heart, the pericardium, the spleen, the kidneys and the suprarenal.

Course and Termination of Cancer of the Mouth and Tongue

The average duration of life of an untreated case is twelve to sixteen months. The mortality of the disease if untreated is 100 per cent. The incidence of glandular involvement is about 80 per cent in hospital patients; it is less in private patients. If untreated all cases will develop secondary deposits. The glands are at first small and fairly hard; sooner or later they break down and become fixed by peri-adenitis and later by the disease spreading to the cellular tissues of the neck. Finally, the mass breaks down, suppurates, and discharges through the skin; a cavity is formed lined by foul granulation tissue and containing necrotic debris of growth. Swallowing becomes progressively more difficult; cough and dysphagia become more and more distressing; and repeated hæmorrhages occur at intervals either from the mouth or from the sinuses in the neck. Pain and discomfort increase and cause insomnia. The final stages of the disease should be kept in mind and remembered before refusing treatment to patients on the grounds that palliation only can be obtained. Neither the disastrous effects on the eventual statistical tables nor the desire to prove the possibilities of one or the other method of treatment should deter the surgeon from combining all methods of treatment in combating the disease. Operations on the neck should not be refused if there is a possibility of removing all the glands on one side of the neck. The planning of the surgical or radiological treatment should be done on a big scale commensurate with the gravity of the disease.

Diagnosis

Difficulty in diagnosis in lesions of the mouth and tongue occurs only in early stages of the disease; in the later stages the clinical evidence is unmistakable. If on clinical grounds diagnosis is not possible and suspicion of malignancy is entertained, recourse should be had to histological confirmation. Biopsy is a certain method of establishing a diagnosis. In some centres it is of general application and no case is treated unless proved by microscopy to be malignant. Some authorities—fewer as time goes on—object to a biopsy on the presumption that it may provoke spread of the malignant tumour. There is no proof either clinical or statistical that biopsy increases the rate of growth or favours dissemination. That this, however, appears to happen in some patients has led to the practice of submitting the lesion to irradiation prior to biopsy, and carrying out the procedure by means of the diathermy knife; as this does not materially affect the histological appearance of the tumour it is advisable to give the patient the benefit, though problematical, of this refinement of technique. The immediate microscopical examination, either of a frozen section or with the ultra-pack, in any case enables the lesion to be treated without delay either surgically or by radiation. In an early and small lesion, biopsy should consist in the local excision of the whole lesion. In the small warty and nodular types of lingual cancer, it is of great importance and should be practised as a routine. In the ulcerative type, the section should be taken from the margin of the ulcer, including the edge, some apparently healthy tissue beyond it, and a portion of the base. Besides the conclusive diagnosis of malignancy, histological examination provides accurate knowledge as to the histological variety of the neoplasm. This is of importance in distinguishing lympho-epithelioma from keratinising carcinoma, and so helps in the decision as to the type of treatment most suitable for the case, while also being to a certain extent a guide as to the dosage of radiation.

Differential Diagnosis

The lesions in the mouth and tongue to be distinguished from cancer are simple ulcers, syphilitic sores, tuberculous lesions, and benign growths. There is no doubt that in some cases any one of these may bear a close resemblance to a malignant growth and the difficulty is increased by the fact that a neoplasm may be superimposed on any one of these conditions.

Syphilis. A primary chancre in the mouth is rare, carcinoma is common. The age incidence is of no importance as both conditions

may occur in young, middle-aged and old patients; no diagnostic importance is to be attached to the fact that a chancre is more likely to be the correct diagnosis in the young. A chancre may occur on the tip of the tongue, on the buccal mucosa, or on the floor of the mouth. In primary syphilis, glandular enlargement is early and widespread, the glands being soft and diffuse, bilateral, and tender. General signs of syphilis follow within a few weeks. Spirochætes are present in the lesion; the Wassermann reaction may be negative. Tertiary syphilis is more difficult to diagnose, especially the gumma which is deep-seated and has not yet reached the surface and so mimics the nodular type of cancer. Both lesions occur on the dorsum of the tongue and start as a nodule deep to the mucosa; a gumma is relatively painless, ill-defined, firm, lumpy, and part and parcel with the surrounding tissue; the progress is slow, and there is no glandular enlargement. Age and sex incidence are of no diagnostic significance. Gummatous ulcers are much more often multiple than single; one lesion may be healing whilst a second is developing, so that they do not present the same appearance. The edges are undermined and less indurated than in carcinoma. The majority of syphilitic lesions occur on the palate and the centre of the tongue anteriorly, a few on the buccal mucosa. In congenital syphilis a lesion may develop in the vallecula. The Wassermann reaction is, as a rule, positive. A negative Wassermann reaction does not preclude syphilis; a positive Wassermann reaction does not exclude malignant disease. One of the grave errors in surgical judgment, and one which is very serious for the patient, is the indefinite prolongation of anti-syphilitic remedies when they do not produce the desired effect. It cannot be too strongly emphasised that the presence of an active syphilitic lesion in the mouth does not immunise the patient against cancer; on the contrary, it should be remembered that the syphilitic tongue and the mouth of an old syphilitic patient are the most fertile soil for the development of cancer. Valuable time must not be wasted in test treatments.

Simple ulcers. The appearance of a benign or traumatic ulcer is that of an acute lesion; the cause of the ulcer is generally ascertainable, such as a foreign body, a sharp tooth, or an injury. A simple ulcer should heal when its cause is removed, and healing is generally very rapid. Papillomata should be removed and examined under the microscope. A tuberculous ulcer is characteristic in appearance (see page 5029), is exceedingly tender, and causes constant pain. It is associated with laryngeal or pulmonary tuberculosis or with lupus of the nose, face and lips.

Importance of Early Diagnosis.

Emphasis must be laid on the vital importance of early diagnosis. In early recognition of malignant disease lies the greatest hope of cure. All methods of diagnosis, especially biopsy, are imperatively indicated if the gravity of delaying treatment is appreciated in its true light. A lesion of the tongue must be suspected to be malignant, and appropriate steps must be taken to rule out malignancy or to establish its presence. Unmistakable signs of cancer should never be awaited. If the lesion *does not respond at once to simple or specific remedies, biopsy should* be carried out.

CARCINOMA OF THE MOUTH AND PLUMMER-VINSON SYNDROME

Hugo E. Ahlbom of the Radiumhemmet in Stockholm drew *attention recently to the association of simple achlorhydric anæmia,* Plummer-Vinson's syndrome, and carcinoma of the mouth, pharynx and œsophagus in women. These observations are original and very important both from the point of view of a new "pre-cancerous" condition which exceeds in importance if not in frequency that of *syphilitic conditions, and also in drawing attention to certain* ætiological factors in cancer of the mouth and pharynx. A somewhat detailed account is therefore thought to be warranted, and the following is based on the original paper by Ahlbom (*Lancet,* Aug. 15, 1936, 331). Simple achlorhydric anæmia among women is *a familiar and fairly common disease.* The *syndrome* has been called "Plummer-Vinson's" syndrome or "dysphagia associated with anæmia." Curiously enough, this disease is hardly known outside Great Britain and the United States. The patients are almost always females, generally between the ages of fifteen and fifty. Anæmia and weakness are of many years' duration. They usually give a history that the teeth were lost early in life, at the age of twenty or thirty, and that fissures or eczema appeared periodically at the corners of the mouth. A distinctive feature is the shrinkage of the opening of the mouth, which is small and rigid, the lips being thin and pale; these changes and the edentulous jaws give the patients a characteristic appearance which suggests the diagnosis. Associated with these signs is a deformity of the nails, the so-called "spoon-shaped nails" or koilonychia. A moderate degree of hypochromic anæmia is always present. The dysphagia is probably due to the atrophy of the mucous membrane usually found in the mouth and pharynx of these patients; the atrophy is most pronounced in the mucosa of the tongue, which in typical cases is completely smooth. These patients have a marked pre-

disposition to mouth cancer; two of Ahlbom's patients, both women, had multiple lesions, one of the patients having five different carcinomata in the lip and mouth, and the other three. The attention was thus drawn to this association of Plummer-Vinson's syndrome and malignant disease of the mouth. Considerable evidence was found at the Radiumhemmet of this occurrence in about *half* of all the women with carcinoma of the mouth and also in the great majority of women with carcinoma of the hypo-pharynx. A case reported by J. McGibbon had this syndrome and multiple carcinomata in the buccal mucous membrane. At the Radiumhemmet in the past five and a half years, out of a total of 150 women with malignant disease of the mouth and pharynx, 70 per cent had signs and symptoms suggesting Plummer-Vinson's syndrome. In the material in Sweden the incidence of cancer of the mouth in women is exceptionally high, viz. 40 per cent, as compared with 15 or 25 per cent in other European countries. The practical significance is that effective treatment is very important in such cases of achlorhydric anæmia and, since iron in large doses has a rapid and almost specific effect, it may thus be a measure which is in the best sense "cancer prophylaxis" Ahlbom urges that the syndrome should command the attention of cancer investigators. The tendency to predisposition to cancer is greater in Plummer-Vinson's syndrome than in syphilis, for at the Radiumhemmet a far greater proportion of patients with carcinoma of the mouth and pharynx have these syndromes rather than syphilis, even though the incidence of syphilis is many times greater in the general population.

TREATMENT OF CANCER OF THE MOUTH AND TONGUE

Radium treatment of cancer of the mouth and tongue is discussed in detail in Vol. I, pages 1576–1589.

CONTACT LOW-VOLTAGE X-RAY THERAPY

In the treatment of malignant growths in the mouth, radium and high-voltage X-rays are recognised and well-known methods of therapy, the results of which command the attention of every clinician. A relatively new method of treatment by *low-voltage X-rays* was introduced about four years ago by Professor H. Chaoul of Berlin (fig. 2731). This new method deserves close attention, and presents many advantages of which convenience, simplicity, and ease of application are by no means the least important points. In my opinion it fills a very useful place in the radiation therapy of superficial malignant growths, and its special adaptability to lesions in the tongue,

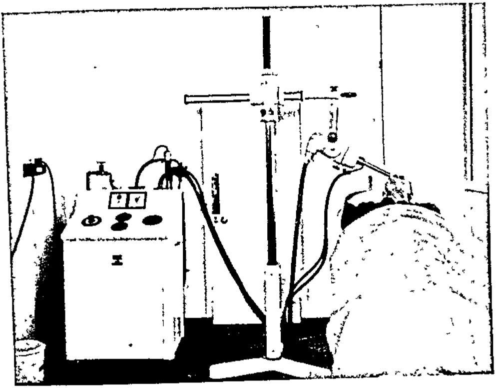

Fig. 2731.—CONTACT LOW VOLTAGE X-RAY EQUIPMENT. X RAY APPLICATOR INSIDE PATIENT'S MOUTH.

palate, floor of the mouth, cheek and lip justifies its description. This new development in X-ray therapy aims at developing a technique of X-radiation similar and comparable to that of radium. The hypothesis on which the work is based is that the superiority of radium to that of X-rays, as observed in the results obtained in the mouth and elsewhere, is not due to the quality of the rays but solely to the physical properties and conditions of application. Chaoul attempted to apply X-rays under conditions similar to radium therapy. The principles of the technique are as follows: to apply the source of X-rays at a very short distance from the lesion (3 or 5 cms.); to apply the X-rays practically unfiltered (0·1 or 0·2 mm. of nickel); and to localise the X-rays by means of suitable small applicators of various sizes and shapes which are applied accurately to the lesion and which protect the healthy surrounding

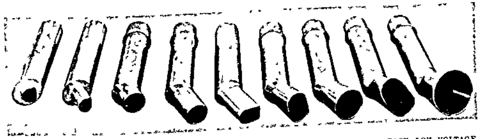

Fig 2732.—APPLICATORS OF VARIOUS SIZES AND SHAPES—FOR USE WITH CONTACT LOW VOLTAGE X-RAY APPARATUS.

tissues. To obtain these conditions a very small X-ray tube of unusual design was constructed; in this tube the target is situated at the extremity of a long metal tube which can be introduced into the patient's mouth (see fig. 2732). Low-voltage X-rays are used, namely 60 K.V., 4 M.A. The principle of the treatment is to space the applications so as to fraction the dose and protract it to a total period of two to three weeks. Daily treatments of very short duration are given. each treatment occupying *three to five minutes*. The total daily dose to each field varies from 250 to 400 " r " and the total dose at the end of treatment is about 4000 to 6000 " r." It will be seen that by bringing the source of X-rays close to the lesion, by using the rays practically unfiltered, and by repeated small doses. a very high total dosage is obtained. *Chaoul* has treated twenty-six lip cases and twenty-eight oral cases. In this country Professor Woodburn Morison at the Cancer Hospital in London, Dr. J. F. Bromley at the General Hospital in Birmingham, and the author in conjunction with Dr. F. M. Allchin at Westminster Hospital have had experience of the method. My own personal experience in the treatment of seventy-five patients with the Chaoul machine has led to the following conclusions: (1) The method is only applicable to superficial and accessible lesions. (2) The immediate biological effect is indistinguishable from that of radium. (3) Total disappearance of a carcinoma in the mouth. lip or tongue is obtained. (4) The scar left after the lesion is healed is soft, supple and healthy. (5) The advantages of the method in suitable cases are very numerous and important; they can be summarised as follows: (*a*) The treatment takes only a few minutes daily. so that not only is hospitalisation not required but the patient can continue his normal occupation; (*b*) absolute accuracy of application is very easily obtained; and (*c*) there is no " operative " or " anæsthetic " risk and there is no trauma such as is inevitable if radium needles are inserted. (6) The reaction of the lesions to treatment, the erythema of the skin, the mucosal peeling, the formation of a membranous deposit of fibrin on the lesion, and the healing are absolutely indistinguishable from those obtained from radium. (7) Although at this early stage it is impossible to express an opinion as to permanence of the results obtained, if the immediate biological effect as observed clinically is identical with that of radium, it is reasonable to anticipate similar remote results. The method is of very great interest to the radiologically-minded surgeon. But it must be emphasised again that it is only suitable for superficial lesions, that the depth dose at 5 cms. from the surface is very small, and that the limitation of usefulness of the Chaoul machine must be strictly understood. If

unsuitable lesions are submitted to treatment, very grave surface burns will occur without arrest of the disease at the depth.

Pre-operative Treatment of the Mouth.

Whether surgery, diathermy or radium is the method of treatment selected, pre-operative preparation of the mouth is very important. A scrupulous toilet of the mouth is essential if a smooth post-operative convalescence is to be achieved. The best results are obtained in edentulous mouths and it is my opinion that every case of cancer of the mouth or tongue would benefit from the removal of all teeth, but the removal of carious teeth, stumps and metal bridges, and the treatment of the gums is imperative. Acceleration of healing following extraction of teeth is obtained by bringing the raw surfaces of the gums together with a few catgut sutures. Clearance of the mouth should precede intra-oral surgical procedures by a few days. Mouth-washes of mild Condy's fluid or weak hydrogen peroxide should be frequently employed; these are more effective if given by a syringe and the mouth irrigated by a nurse than if the treatment is left to the patient's own discretion. Such pre-operative measures accustom the patient to a routine which is to be followed after the operation. In the presence of ulceration the lesion should be painted with a solution of arsenic such as novarsenobenzol in glycerine and water. The solution should be applied to the lesion after the mouth has been irrigated.

Anæsthesia.

Although small lesions situated in the anterior part of tongue, the roof of the mouth and the buccal mucosa can be treated under local anæsthesia, general anæsthesia is preferable. Relaxation of muscles increases the operative comfort of the surgeon and relieves the mental distress of the patient. Accuracy of the intra-oral operation is ensured and difficulties caused by bleeding and salivation are diminished. For most operations in the mouth preliminary basal anæsthesia is of very great help. Evipan or avertin is superior to morphia and hyoscine, and the former is in the majority of cases the more suitable. It may be sufficient to carry out the operation; if supplementary anæsthesia is required, and especially so in dealing with the posterior or inferior surfaces of the tongue or the hard palate, intra-tracheal intubation is the method of choice. The tube should be passed through the nose and the pharynx plugged.

DIATHERMY EXCISION IN ORAL CANCER

Indications.

(1) If radium is not available or is contra-indicated.

(2) For small lesions in the hard palate or the tip of the tongue in selected cases.

(3) For local recurrences after surgical excision of part of the tongue in the presence of marked fibrosis, dense scarring, and advanced syphilitic glossitis.

(4) For local recurrence after radium treatment in the presence of sepsis at the site of the recurrence or in its neighbourhood.

(5) For lesions invading bone.

(6) For the excision of a residual mass of scar tissue following an apparently successful irradiation.

(7) For sub-total or partial glossectomy in advanced cancer of the tongue involving the anterior or dorsal portion, in the presence of œdema and sepsis. This is chiefly a palliative measure which relieves symptoms, increases the comfort of the patient, improves speech, diminishes salivation, and arrests hæmorrhage.

General Considerations of Surgical Diathermy in Oral Cancer

Diathermy can be used in surgical work either for the destruction of tissue by coagulation or for direct excision, similar to excision with the scalpel. By the use of high frequency currents of high amperage and lower voltage a coagulating current is obtained; by means of high voltages and higher frequencies, using an undamped oscillation in the nature of 3,000,000 per second, a cutting effect is produced; healing follows with very little scar formation. High frequency diathermy currents are produced by passing an alternating current of 150 to 250 volts, obtained from a main A.C. supply or by means of a rotary converter, through the primary coil of a transformer. A high voltage alternating current is developed in the secondary coil, and this is connected to a series of condensers which store up the electrical charge until the voltage is sufficiently high to jump over a spark gap. Whilst this current is oscillating in the electrical circuit, it is taken up by a series of resonance coils in a second circuit which is connected to the patient. In surgical diathermy two electrodes are employed. The indifferent electrode is attached to the skin of one of the limbs or to the back; the indifferent electrode is large and makes contact with an area of skin of between 6 and 8 inches square. It is usually made of a lead plate and is covered by a small towel soaked in normal saline. The active electrode is small, such as a fine needle, a narrow-bladed knife, or a small metal sphere. The current passes from the indifferent electrode and is discharged at the point of contact with the active electrode. The extent and severity of coagulation are regulated by: (1) The intensity of the diathermy current; (2) the time the electrode is in contact with the tissues; and (3) the nature of the electrical conductivity of the tissues; muscle and skin are more rapidly coagulated than fat and hard fibrous tissue. Pressure on the electrode should be avoided and a rapid light stroking movement employed. Coagulation by diathermy is bloodless, as the vessels and the lymphatics are sealed off by the current; cutting diathermy, if slowly and skilfully used, diminishes the loss of blood to a very great degree; but it does not abolish it, and the vessels of any size must be picked up in the usual way.

Touching the forceps holding the vessels will coagulate the cut surface, and ligatures are only necessary for the larger vessels. The use of the diathermy requires familiarity with the specialised technique. With a reliable apparatus and in the hands of surgeons who use it constantly much time is saved, bleeding is negligible, and the operation is as clean as with the scalpel. The question of anæsthesia in diathermy operations is very important; ether must not be used as there is a very great risk of an explosion occurring in the patient's mouth. Gas-oxygen-chloroform by the intra-tracheal method through a nasal catheter, as described by Magill, is the method of choice. The removal of an ulcerated area

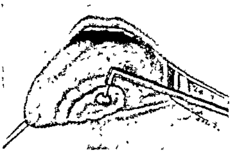

Fig. 2733.—Diathermy to tongue with button electrode.

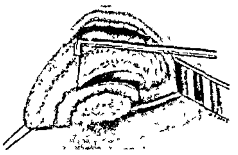

Fig. 2734.—Diathermy to tongue—excision with needle.

(By kind permission of Mr. W. Douglas Harmer and the "British Journal of Surgery")

or of a tumour is identical with that with the scalpel; excision may with advantage be preceded and followed by surface coagulation. Figures 2733 and 2734 illustrate the method as described by Douglas Harmer (*Brit. Journ. Surg.*, 1928, XV, 661).

Healing after Diathermy.

When excision of a lesion in the mouth is carried out with the diathermy, the wound in the tongue *should not be sutured*; healing by first intention which is easily obtained in the skin is exceptional in mucous surfaces. The area treated or left from the excision becomes coated by a white exudate adherent to the underlying tissue. A superficial slough forms and is separated in 7–10 days. Healing takes place from the periphery. Following the operation there is some œdema of the surrounding tissues but very little pain. Separation of the slough may cause some bleeding. Severe hæmorrhage is exceptional in the absence of gross sepsis or residual disease. If the area excised or coagulated is in close proximity to the lingual vessels, and if the operative procedure is of great magnitude, preliminary ligation of the lingual artery or external carotid is indicated. Following the separation of the slough, healing is rapid and the resulting scar supple.

TREATMENT OF CERVICAL LYMPHATIC FIELDS

It is agreed by most authorities that all cases of cancer of the mouth or tongue should have some form of treatment to the cervical lymphatic area. Without such treatment the risk of secondary deposits in the cervical lymphatic glands is very great, and even if the primary lesion in the mouth is adequately treated and completely eradicated, the risk of metastasis is always present and the patient cannot be considered as having been reasonably safeguarded against the disease. In my opinion, even when there are no clinically palpable cervical glands, it is imperative to treat the neck. It should be a law in the treatment of oral and lingual cancer that no patient is left to the hazards of chance by leaving the lymphatic field without treatment. It is, therefore, strongly prejudicial to the patient's outlook to adopt an expectant policy, to keep the case under observation and to wait till a gland *is* palpable. The natural history of malignant growths in the mouth shows that the vast majority develop metastases; therefore, to leave the neck untreated is to penalise the early case. The position in cancer of the lip is quite different, the frequency of metastasis is very much smaller, and it is therefore quite legitimate in lip cases to postpone the treatment of the neck if no glands are palpable. The choice of the treatment requires familiarity with the disease, surgical acumen, knowledge of the possibilities of radiation therapy, and an accurate assessment of each case as to the risks involved and the likelihood of a cure if major procedures are adopted. If no glands are palpable, or if the glands are inoperable, the treatment should be by radium or X-rays (see Vol. I, pages 1584–1586). If the glands are palpable, clinically malignant or suspected to be so, surgical treatment should be considered. Minor operations on the neck, such as the removal of the enlarged glands only, or the clearance of the submaxillary triangle alone, are very disappointing in their end-results in most cases. Although practised by some and advocated by a few, the limited operations on the neck are unsatisfactory, unreliable, and against all principles of the surgery of malignant disease. Although the conditions are not absolutely comparable, a partial operation on the axilla in cases of cancer of the breast would be universally condemned; for the same reasons it is undesirable to carry out partial or incomplete removal of the cervical lymphatics. The operation of choice is an extensive excision of the cervical fascia and fat with *all* the glands as widely and as extensively as possible. Such an operation is impossible, or possible only with added and unnecessary risk and difficulty, unless the sterno-

mastoid muscle and the internal jugular vein are removed. This entails a "block dissection" and is indicated when the following conditions apply: (1) *The primary growth in the mouth must be entirely healed with a reasonable prospect of permanency.* The surgeon must be satisfied that the result of treatment in the mouth, be it surgical or radiological, has been successful and that the disease is unlikely to recur locally. (2) *The glands in the neck should be palpable and clinically operable.* It is not justifiable to submit the patient to a block dissection if the neck is clinically free from enlarged glands, when radiological methods (needling, collar, bomb or X-rays) would do equally well to safeguard against recurrence. The question: "Does irradiation *prevent* metastasis?" is a problem of very great practical importance. Some irradiated necks (perhaps inadequately irradiated?) develop glands in spite of the radiation; other patients who had proved malignant cervical glands are completely rid of them by radiation only. The result of a very careful analysis of the after-histories of such patients, and the study of the failures perhaps more than the study of the successes, have shown that if radiation is given to the neck to prevent metastasis of squamous-celled carcinoma, such radiation must be of the highest possible intensity, and the dosage the greatest the patient can stand, and no less than if actual malignant glands were present. It is not so much a question of preventing metastasis by irradiating a neck presumed to be normal, as of irradiating actually or potentially malignant glands at a stage when the disease is so early as to be unrecognisable clinically. It is therefore a totally different problem from prophylactic irradiation. (3) *The general condition and the age of the patient must permit a major surgical operation.* If the above conditions are not all present, block dissection should not be undertaken and the patient should be submitted to radiation treatment.

Block Dissection.

The anæsthetic of choice is a basal narcotic associated with local or regional anæsthesia. It is admittedly a greater strain on the surgeon to operate under local anæsthesia. The use of a basal narcotic eliminates the objection of the mental strain on the patient. The advantages of a local anæsthetic to the patient outweigh the disadvantages to the surgeon. Perfect anæsthesia can be obtained by the injection of the second, third and fourth cervical nerves at their exit from the intervertebral foramina on both sides of the neck; a 2 per cent novocaine solution is used (see Vol. II, pages 1893–1895), or a local infiltration with $\frac{1}{2}$–1 per cent novocaine solution may be employed; the latter is an easier procedure but the wide infiltration of the cellular tissues of the neck

is not without its drawbacks where malignant glands are present. If a general anæsthetic is used, gas and oxygen are sufficient; if given through an intra-tracheal catheter, the anæsthetist is out of the surgeon's way, the face can be completely covered up to the chin, and the operation field separated from the anæsthetist.

Operation.

The operative steps are as follows: The skin is divided by an incision extending from the mastoid process to the sternal end of the clavicle, between the two heads of the sterno-mastoid muscle (fig. 2735). A second incision starts below the chin slightly beyond the middle line and turns downwards and outwards to meet the first incision below the level of the hyoid bone. Three skin flaps are next dissected, the first upwards with the base at the level of the mandible, the second inwards and downwards, and the third backwards. These flaps take up the platysma and skin and nothing else; the fat should not be taken up with the flaps. It must be kept in mind that the object of the operation is to remove *en bloc* a complete triangular sheet of deep fascia together with the fat, the glands, the sterno-mastoid muscle, and the jugular vein. This dissection is started at the lowermost corner of the incision (fig 2736). The deep fascia is divided above the clavicle outwards and upwards along the mid-line; the lower end of the sterno-mastoid is divided completely across, the internal jugular vein is identified, separated by the finger from the deep structures, isolated for about 1 inch, ligatured twice and divided between the ligature (fig. 2737). The deep fascia is then incised upwards from the clavicle to the submental area, and is next reflected outwards by a few strokes of the scalpel leaving the infra-hyoid muscles bare and denuded of fascia. As the dissection proceeds outwards, the inner edge of the sterno-mastoid is reached, and the layer of deep fascia on its inner aspect is taken up together with the muscle; the common carotid artery is then exposed and is separated with its sheath from the jugular vein. When the dissection has reached the level of the carotid bifurcation, attention is turned to the supraclavicular fossa which is cleared by dissecting the fat and all the glands upwards; the transverse cervical veins require ligation. The external and anterior jugular veins are next clamped and divided; the omo-hyoid is cut across and part of the posterior belly removed. The dissection of the deep fascia and its adherent structures is continued upwards till the lower jaw is reached; the mylo-hyoid is exposed, and the submental glands are freed and turned outwards. The submaxillary triangle is next dealt with; the facial vein is divided, the submaxillary salivary gland enucleated, and Wharton's duct cut and ligatured.

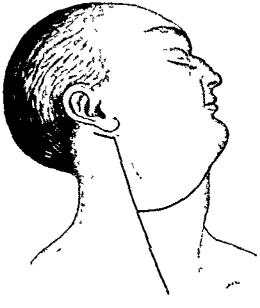

Fig 2735.—BLOCK DISSECTION—INCISIONS. (*Spencer and Cade.*)

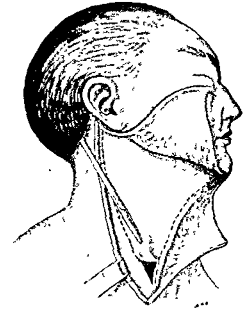

Fig 2736 —BLOCK DISSECTION SHOWING REFLECTION OF FLAP OF SKIN AND PLATYSMA AND BEGINNING OF DISSECTION OF DEEP FASCIA

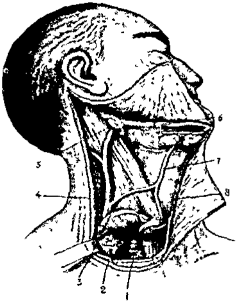

Fig. 2737.—BLOCK DISSECTION SHOWING DIVISION OF STERNO MASTOID MUSCLE, AND LIGATION AND DIVISION OF INTERNAL JUGULAR VEIN

1. Internal jugular vein divided
2. Fat in supraclavicular fossa.
3. Sterno mastoid—clavicular end divided
4. External jugular vein.
5. Parotid.
6. Facial vessels divided
7. Anterior jugular vein
8. Incision into deep fascia.

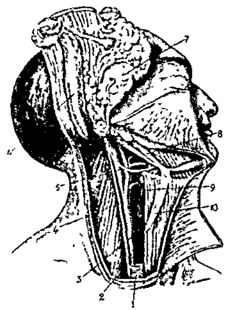

Fig 2738 —BLOCK DISSECTION. FINAL STAGES INTERNAL JUGULAR VEIN AND POSTERIOR BELLY OF THE OMO-HYOID HAVE BEEN TAKEN UP WITH FAT AND FASCIA

1. Internal jugular vein divided.
2. *Vagus nerve.*
3. Common carotid artery.
4. Descendens hypoglossi nerve.
5. Hypoglossal nerve
6. Internal jugular vein.
7. Fat.
8. Digastric muscle.
9. Superior thyroid artery.
10. Anterior belly of omo-hyoid

(*Spencer and Cade*)

Care should be taken to preserve the hypoglossal nerve; the posterior belly of the digastric is carefully denuded of all fascia. The dissections from below upwards and from the mid-line outwards meet at the level of bifurcation of the carotid; the glands in this area are numerous and sometimes large; very careful manipulation is necessary so that contamination of the wound may be avoided. The lower pole of the parotid gland is exposed, and the superficial veins are divided (see fig. 2738). The upper end of the internal jugular is defined and divided between ligatures. The sterno-mastoid muscle is divided as near the mastoid process as possible. The division of the muscle and of Wharton's duct is preferably done with the diathermy; the rest of the operation is performed with the scalpel or with blunt-pointed curved scissors. The clearance of the posterior triangle should be complete, and the spinal accessory nerve saved if possible but only without detriment to the completeness of the operation. It is advantageous to ligate all vessels as the operation proceeds and thus avoid obscuring the field by numerous artery forceps. The wound is closed with a small drain in each of the three corners. If hæmorrhage is well controlled throughout the operation and if the anæsthesia is satisfactory there is but little shock. Following the operation there occurs some œdema of the side of the face which disappears in ten to fourteen days; there is also slight lower facial weakness which recovers in most cases. The complete removal of the whole sterno-mastoid does not handicap the patient subsequently, and full and normal movements of the neck are the rule.

Bilateral dissection of the neck is indicated in a few cases, when the lesion is centrally situated in the tongue or floor of the mouth, or if it transgresses the mid-line. In such cases the ligation of the second internal jugular vein should be either avoided or postponed for 2–3 weeks. It is generally sufficient to clear the submental, submaxillary and carotid glands on the second side. If a bilateral operation is contemplated from the beginning, an H-shaped incision is made as follows: two longitudinal incisions, slightly curved, are made, one on each side of the neck, along the anterior borders of the sterno-mastoid muscles; these two incisions are joined together by a curved, transverse incision, with its concavity downwards, and half-way between the jaw and the thyroid. By dissecting the central flap upwards and the lateral flaps outwards both lymphatic fields are exposed.

CHAPTER IV

Benign Tumours and Cysts of the Mouth and Tongue

PAPILLOMATA

The term papilloma is applied to local papillary new growths, which are villous in appearance, and composed of units which grow on a slender stalk. The tongue and the mucous membrane of the mouth are frequently the seat of such tumours. They may arise from cutaneous or mucous surfaces and develop in any part of the mouth or tongue. Their shape depends on the local conditions of the stroma from which they develop. Chronic irritation and the consequent hyperplasia of the surface epithelium plays a part in the ætiology of some of these tumours; others can be traced to some specific infection or to repeated trauma. They are therefore subdivided into the three following groups: (1) *Congenital papillomata;* these have been observed in newly-born infants and young children. Butlin describes multiple papillomata of the fungiform papillæ and warty lesions on the dorsum of the tongue in a young boy, and also localised sessile warty tumours on the dorsum of the tongue in a baby of ten months old. (2) *Inflammatory papillomata;* it is doubtful if this variety is an instance of a true benign tumour. Instances of cutaneous and mucous warts due to infection are common, and such lesions as venereal warts, condylomata, and gonococcal warts on the vulva and anus are well known. In the mouth they are seen in infants with Riga's disease; in adults in secondary syphilis, as a result of irritation from a carious tooth with sharp edges, and superimposed upon various forms of glossitis. These lesions are infective or traumatic in origin. (3) *Leukoplakic papillomata;* patches of leukoplakia are very prone to develop papillomata. At first they are short, white, flat outgrowths which spread on the surface of a patch of leukoplakia; they are velvety in appearance and essentially centrifugal in progress; sooner or later this type of leukoplakic papilloma develops centripetal characters and is transformed into a carcinoma of the papillary type. The macroscopical appearance of these lesions is that of a flat or villous tumour, red or white in colour, sometimes on a fine pedicle, at other times growing from a broad base (see fig. 2739); in size they vary from a single circumscribed soft wart to a series of lesions which eventually form into one bulky mass which occupies the palate, the cheek, the tongue, or the floor of the mouth. They are painless unless infected; they bleed from accidental trauma or interference by the patient; they cause symptoms only by their bulk or from infection. Absence of symptoms should not deter the doctor from advising adequate treatment. The main interest of papillomata of the tongue and mouth centres in their differential diagnosis from malignant epithelial growths of the papillary type and in their tendency to undergo metaplasia, and hence in their treatment. Differential diagnosis can only be obtained with absolute certainty by means of a biopsy. The tendency to undergo malignant changes is

Fig. 2739.—Papilloma of the tongue. Centrifugal but not centripetal overgrowth; no sub-epithelial round-celled infiltration. A benign lesion.

(*Mr. W. G. Spencer's case.*)

heralded by an increasing rate of growth, bleeding, ulceration, hardness of the base from infiltration, and hence fixation and loss of mobility. It must be remembered that a number of cases of carcinoma of the mouth begin in the papillary form, and such cases are clinically indistinguishable from papillomata (see figs. 2725 and 2726).

Treatment.

Treatment of warty benign growths is of great importance and is a prophylactic measure against local malignant disease. The warts can be dealt with by one of the following methods: (1) The lesion can be excised with the scalpel and the base sutured. (2) The wart can be excised with the diathermy needle and the base left unsutured. (3) It can be destroyed by the diathermy by gradual coagulation. (4) It can be destroyed by insertion of radium needles at the base of the lesion. (5) It can be destroyed by means of contact X-radiation. The choice of the method depends upon the facilities available. From the author's personal experience the following important points in the treatment of benign papillomata must be emphasised. (1) These lesions should not be treated by the application of caustic such as silver nitrate or by carbonic acid snow. Such treatment leads to early and rapid local recurrence, and at times to rapid development of malignant disease. (2) If *surface* radium is used it should be a continuous, prolonged, and very effective irradiation by an intra-oral applicator made to fit the patient's mouth; the local intermittent application of small radium plaques, indifferently screened (meant really for skin lesions), is a very dangerous practice and is undoubtedly, in the mouth, a potent weapon for the hastening of malignant changes. Radium, therefore, is a two-edged weapon; if applied adequately it will destroy a papilloma, while if applied inadequately it may stimulate a change leading to an epithelioma. Surface X-radiation by the contact low-voltage method seems to be the ideal method and is the most acceptable to the patient. Some papillomata may remain

benign for very long periods, but as neither the cause of their malignant transformation nor the time at which this may occur can be predicted or assessed clinically, all papillomata in the mouth should be dealt with without delay. Sampson Handley has studied the potential powers of papillomata to develop into cancer, and his work is convincing to the extent that, although the primary cause of malignancy is quite unknown, papillomata must be considered as a powerful secondary cause. Ewing crystallises the position succinctly as follows: "The development of clinical signs of malignancy is probably much more frequent than a corresponding change in the growth capacities of the tumour. Such a change may be simulated when an original carcinoma is associated with secondary simple papillomata on the surface or in the vicinity which mask the malignant character, or an originally malignant process may for a time present a simple papillomatous appearance. The first two conditions are exhibited in papillomatosis of the intestine, and the last in some malignant papillomata of the larynx. Nevertheless, the gradual transformation of a benign papilloma into a malignant tumour has been fully demonstrated in the cervix uteri, bladder, larynx, and other locations and has usually followed the trauma of incomplete operation, or prolonged chronic inflammation." (J. Ewing, *Neoplastic Diseases*, 3rd Edition, Saunders, 1934.)

MUCOUS- AND SALIVARY-GLAND TUMOURS IN THE MOUTH AND TONGUE

The so-called "parotid tumour" or "mixed tumour" is common in the parotid gland, less common in the submaxillary gland, and has been described in Vol. II, pages 1875–1880. That such tumours occur in the mouth, the tongue and the palate is less well known, and this alone justifies an account of the condition in these unusual situations. From time to time, records of individual cases are published, always as a tumour of mixed type in an unusual situation. In a monograph by Ahlbom from the Radiumhemmet, these various tumours were studied and the name of "mucous- and salivary-gland tumours" aptly applied to them. Besides the two main salivary glands, such tumours occur in the tongue, soft and hard palate, cheeks, lips, and also in situations outside the oral cavity (auditory canal, larynx, lachrymal glands, etc.). Descriptions of such tumours date back to Sir James Paget who, in 1851, described a "parotid" tumour in the lip, while Stephen Paget, in 1886 (St. Bartholomew's Hospital Reports, 1886, 22, 315), collected 31 cases of tumours of the palate; in all, enucleation was found not only possible but easy and the tumours were considered benign. Since then an extensive literature on the subject has accumulated and individual cases are being reported from time to time. The aggregate of these cases shows that the disease is not at all uncommon. In 1935 a monograph on these tumours, both in the main salivary glands and in outlying situations, was published by Hugo E. Ahlbom. The material on which the study is based consists of 254 cases treated during a period of 23 years. The name applied by Ahlbom to this type of tumour in the mouth and in the main salivary glands is "*mucous- and salivary-gland tumours*," adopted from Krompecher. It seems that this name has come to stay and will eventually replace such terms as "mixed parotid tumour" or "salivary-gland tumour." This name implies that at least part of the tumour arises from mucous glands or salivary glands in an adult or embryological state. Histological studies of these tumours, both in their main and accessory situations, have led to different conceptions as to their origin. The various views can be summarised as follows:

(1) That these tumours are an overgrowth of embryonal rests, being mixed adeno-myxo-chondro-fibromata, which arise in connection with the periosteum of the mandible, and Meckel's cartilage. Malignant changes occur in such previously benign tumours. (2) That they arise from the endothelium of the lymphatics and capillaries. Some cells undergo mucoid degeneration, others form fibrous tissue. (3) Billroth and others called these tumours "cylindromas" arising from the epithelial cells of the alveoli and ducts. It is evident that various authorities ascribed to these tumours either a mesenchymal or an epithelial origin or a dual nature.

Clinical Features.

The frequency of mucous- and salivary-gland tumours, according to various writers, varies from 1·2 to 5·3 per cent of all tumours. Of all these, the majority (75 per cent) are in the parotid or submaxillary glands. Of the rarer situations the palate is the most common site. From the Studies by Wood (*Ann. Surg.*, XXXIX, 1904), Schreiner and Mattick (*Ann. Journ. Rœntgen.*, 1929), and D. H. Patey (*Brit. Journ. Surg.*, 1930, XVIII, 241), together with the cases from the Radiumhemmet, Ahlbom tabulated the relative frequency of the situation as follows:

	Radiumhemmet	Wood	Schreiner and Mattick	Patey
Parotid region	177	26	45	38
Submaxillary region	13	13	7	6
Sublingual region	2	–	–	1
Mouth	6	1	–	1
Lip	2	4	1	1
Soft palate	6	1	3	2
Hard palate alveolus etc.	31	1	6	3
Tongue	3	–	1	1
Oro-pharynx	5	2	2	–
Naso-pharynx	1	–	–	–
Ear (external and middle)	2	–	–	–
Larynx and trachea	*3*	–	–	–
Orbit (lachrymal glands)	1	–	–	–
Skin	2	–	–	–
Total	254	48	65	53

From the above table and from other references it is seen that whereas in the case of the lips and buccal mucosa the tumours are of great rarity, in the palate, on the other hand, they are not uncommon. As regards age distribution the frankly benign tumours occur mostly in the fourth decade and those of semi-malignant and malignant nature chiefly in the sixth decade. According to the statistics of the Radiumhemmet, the benign variety occurs more frequently in women (65 per cent) than in men (35 per cent), whereas the malignant type occurs in equal proportion in men and women.

The symptoms produced by the intra-oral group of tumours, chiefly the palatal ones, were mainly discomfort, pain, bleeding, difficulty in swallowing, and inability to keep the upper denture in position, but in most patients the disease

causes no symptoms at all and the presence of the tumour is either discovered accidentally or the development of further symptoms is awaited before the doctor is consulted. The tumours in the cheek or palate are round or oval swellings covered with normal (non-ulcerated) mucous membrane, slightly yellowish in colour, smooth when small in size, and nodular when larger. They may grow to a considerable size; cases have been described where the tumour has perforated through the hard palate into the maxillary antrum. One of my patients had such a tumour for sixteen years; it had grown backwards into the oro-pharynx and finally downwards on the aperture of the larynx causing obstruction; this patient had a tumour the size of a tangerine orange (fig 2740), for which a tracheotomy had been performed six years previously In the tongue these mucous- and salivary-gland tumours may occur in the tip or inferior surface, possibly from the

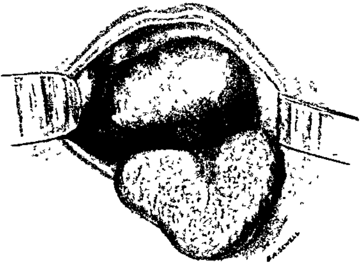

Fig 2740.—MUCOUS AND SALIVARY-GLAND TUMOUR OF THE PALATE. THE LESION EXTENDED FROM ONE TONSIL TO THE OTHER AND BACKWARDS AND DOWNWARDS, OBLITERATING THE NASO-PHARYNX AND OBSTRUCTING THE UPPER LARYNGEAL OPENING A SMALL TUMOUR HAD BEEN REMOVED FROM THE SOFT PALATE TEN YEARS PREVIOUSLY. THE PATIENT ALSO HAD A VERY LARGE TUMOUR IN THE RIGHT PAROTID REGION.

(*From "Diseases of the Tongue," Spencer and Cade, H K. Lewis,* 1931)

glands of Blandin, and also in the vallecula. They are encapsuled and benign and are commonly described as adenomata. As these tumours grow in size and cause difficulties by their position or size and also as they do at times undergo malignant changes, treatment is indicated. Ahlbom emphasises the need for early treatment in all cases; his conclusions are drawn from a very careful study of the largest series of cases yet published, accumulated over a period of over twenty-three years, and requiring six years of continuous work to analyse and interpret. These conclusions must command attention and will no doubt stimulate further advances in the treatment of such tumours; they are as follows: (1) Practically all cases of mucous- and salivary-gland tumours should be treated, the only exception being impairment of general health to a severe degree or advanced old age. (2) Early treatment is indicated. (3) Benign, slowly growing, superficially situated tumours should be enucleated without pre-operative radiation; in all other cases treatment should start with fractional external radiation. (4) Most tumours of this type are either radio-resistant or only slightly radio-sensitive; they should be

irradiated with moderate doses and operated upon. The choice of the method of operation depends upon the nature of the tumour, and this should be ascertained as accurately as possible. (5) Radio-sensitive tumours should be given a large dose of external radiation or a combination of external and interstitial irradiation. It is wiser to use radio-surgery for the most part in tumours of this type. (6) After operation on the benign or semi-malignant tumours, radium should be placed in the wound cavity (7) In operations on tumours in the oral cavity, diathermy should be used if possible. (8) Excision of lymphatic glands need not be performed unless enlarged glands can be palpated and do not disappear after radiation. (9) Even if these principles are followed, the treatment must always be adapted to a certain extent to the individual facts of every case.

BENIGN CONNECTIVE TISSUE TUMOURS

Lipoma.

Lipomata are occasionally seen in the buccal cavity, either in the substance of the cheek or in the tongue. They generally occur after the age of fifty and most frequently in the sixth decade The following types are known: (1) Single, superficial tumour tending to become pedunculated; (2) deep-seated intramuscular; (3) multiple; and (4) diffuse. The single variety is commonly found at the borders of the anterior half of the tongue. It is covered by smooth, thin mucous membrane devoid of papillæ, it is soft and pseudo-fluctuating, yellowish in colour, grows slowly, and causes no symptoms except by its bulk. If it causes symptoms it should be excised The deep-seated variety is more difficult to diagnose and may be mistaken for a dermoid cyst or a soft fibroma; if it comes near to the surface, especially on the inferior aspect of the tongue, its yellow colour distinguishes it from the latter. Treatment consists in enucleation. Multiple lipomata and diffuse lipomata occur in association with similar lesions elsewhere, particularly in the subcutaneous tissues of the neck. They require no active treatment unless giving rise to symptoms, when excision is indicated.

Chondroma and Osteoma.

Bone and cartilage are found in congenital tumours of the tongue such as teratomata As separate clinical entities they are extremely rare. Most cases of true osteoma of the tongue have been found in women. They are slow-growing, generally pedunculated, painless, small in size, round or oblong in shape, covered with normal mucous membrane, and hard on palpation. On section, these tumours show a normal outer layer of stratified epithelium lined by a layer of connective tissue merging imperceptibly into periosteum; in the centre is compact bone with Haversian canals and osteoblasts. The tumours are, of course, opaque to the X-rays, and if such an examination is carried out the diagnosis is established. Treatment consists in simple removal.

Rhabdomyoma.

These tumours are composed of embryonic muscle-fibres; the nuclei are large and deeply staining, the protoplasm lightly staining and rich in granules. Such tumours have been found in the dorsum of the tongue in young children and in adults; they are, as a rule, encapsulated. Cases have been reported by Ritz (*Med. Klin.*, 1926, XXII), Geoffrey Keynes (*Brit. Journ. Surg.*, 1926, XIII), and others. They are easily removed and do not tend to recur. The clinical diagnosis is very difficult, most cases being mistaken for fibromata.

Fibroma.

Fibromata are slowly growing tumours of undetermined origin. They consist of fibroblasts, fibrils, and blood-vessels and lymph-vessels. The cells are larger and more numerous than those of normal adult connective tissue. They vary in consistency and rate of growth. They occur in the tongue and mouth, and are noted sometimes from birth, in other cases beginning in a middle-aged patient. They are generally situated on the dorsum of the tongue, either in the mid-line or on the edge; the mucous membrane over them is intact, but is generally adherent to the underlying tumour and devoid of papillæ. Most fibromata are small, hard, roundish tumours; occasionally they are pedunculated. A *xanthoma* closely resembles a fibroma; it occurs in patients with diabetes, and is a type of fibroma characterised by an abundance of lipoid granules in large polyhedral and spindle-shaped cells. It may be the only xanthomatous lesion present, or may occur in patients with similar tumours in the eyelids, pharynx, or in the skin. Simple

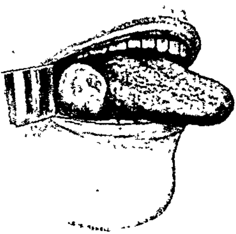

Fig. 2741.—Neurofibroma of the tongue. The mucous membrane was intact.

Fig 2742.—Microscopical appearance of tumour illustrated in *Fig* 2741.

excision both establishes a diagnosis and rids the patient of the small tumour. A *neurofibroma* may occur in the tongue either as a single localised lesion (figs. 2741 and 2742) or as a diffuse neurofibromatosis of the whole or half of the tongue. It may be the only lesion or part of a diffuse neurofibromatosis. The histological structure is that of a plexiform neuroma.

Epulis.

Epulis is a term applied to a lesion situated on the alveolar border in close relationship to the gum around a tooth. It is regarded as a borderline lesion, either inflammatory or neoplastic in nature. It originates from the mucous membrane close to the periosteum of the alveolus. It is considered as a benign tumour of connective tissue origin. It occurs with equal frequency in both upper and lower jaw, more frequently in women than in men, and generally in childhood or in early adult life. In order of frequency, an epulis appears chiefly near the canine, then the bicuspids, the first molars and the incisors. On histological examination *three* varieties are recognised: (1) *Fibrous epulis* or *fibroma;* (2) *fibro-angiomatous epulis;* and (3) *giant-celled epulis.* Although histologically benign,

they behave at times clinically as locally malignant tumours. The tumour starts as a small projection between two teeth which it loosens, and grows outwards over the alveolar margin. The mucous membrane over the fibrous type is normal in appearance. The tumour itself is a small, round, red, vascular nodule, varying from 1–2 mm. in size to that of a cherry It does not ulcerate till very late and then, as a rule, following trauma. Removal is indicated in all cases ; this should be done preferably by diathermy when excision is followed by fulguration of the alveolar margin.

Vascular Tumours

Nævi or *angiomata* not infrequently occur in the mucous membrane of the lips, buccal mucosa, and tongue They are nearly all congenital in nature although some of the lesions do not appear till a few years after birth. They may be single or multiple, and the latter usually involve areas of the palate and cheeks, gums and lips as well as of the tongue (fig. 2743) The *capillary* and the *cavernous* types may be present in the same patient. The former cause no symptoms except occasional bleeding caused by trauma , the latter may increase in size sufficiently to cause

Fig 2743.—Multiple nævi and angiomata in the tongue and mouth of a child aged 7 years. Lesions were present on the soft palate, the buccal mucosa, the gums, the lower lip and the face

some alteration in speech. The lesion appears as a patch of varying size, blue, purple or red in colour ; it is compressible, and when this is done with a glass spatula the colour is seen to disappear, but returns rapidly when the pressure is released ; the tumour does not pulsate. A localised lymphangioma is similar in character but less vascular, and is composed of a series of vesicles, white, red and blue, separate from each other and forming a tumour projecting above the surface of the tongue. Such a tumour is soft in consistency, circumscribed, and painless, tends to increase in size if not treated, and bleeds if traumatised. It does not tend to undergo malignant changes.

Treatment.

Excision is only suitable for nævi of very small size ; in the case of larger tumours or lesions of wide superficial extent, excision becomes a formidable procedure owing to the profuse venous and arterial hæmorrhage. Such cases can be treated by electro-coagulation with a diathermy. The needle is placed into the tumour, the current allowed to pass for a few seconds and the needle withdrawn, this process being repeated a dozen times or more. An alternative to diathermy is the insertion of radon seeds. These must be of very small dimensions so that the trocar employed for their introduction should not cause bleeding ; 0·75–1 mc. per seed is used ; about one seed to each cubic centimetre of tissue is required ; seeds

are left in position for twenty-four hours and then withdrawn. Complete disappearance of the tumour follows; if residual small areas persist, they are treated again after an interval of a few weeks.

Macroglossia.

Macroglossia, or enlargement of the tongue, may be due to muscular hypertrophy, to neurofibromatosis, or to lymphatic hyperplasia. In all three varieties the tongue is enlarged, at times too large for the mouth, speech is impaired, and the surface of the tongue undergoes changes partly due to the original cause of the disease and partly to pressure of the tongue on the gums and teeth.

Muscular hypertrophy occurs mostly in mentally defective patients, particularly congenital imbeciles or cretins. The enlargement is symmetrical and generalised. The condition remains stationary, but secondary changes occur if the tongue is constantly exposed to the air. Simular changes and enlargement may be due to mercurial excess in the treatment of syphilis or to chronic inflammatory changes. The condition requires no treatment, but in selected cases diminution in size of the tongue can be obtained by wedge-shaped central resection, or by marginal resection.

Lymphangiomatous macroglossia is due to dilatation of lymph spaces. It may be congenital or acquired. The dilatation may be due to obstruction of lymphatic vessels following attacks of inflammation or to a hyperplasia of the lymph spaces and the surrounding tissues. The lymphangiectasis may be diffuse or localised, forming clinically a tumour—lymphangioma or lymphatic nævus. The dorsal surface of the tongue is covered by a group of dilated vesicles containing clear lymph. When the condition is widespread, the muscle-fibres of the tongue become separated by the dilated lymph spaces and the following changes occur: (1) Thin-walled coiled arteries replace the capillary loops between the vesicles. (2) The veins become dilated, tortuous, and more numerous. (3) Round-celled infiltration accompanies the dilatation of the lymphatic vessels, and collections of round cells form nodules in the fibrous and muscular tissues of the tongue. (4) The muscular fibres are compressed, undergo atrophy, and in some places disappear entirely. The tongue undergoes progressive enlargement and eventually becomes too large to be retained in the mouth. The surface of the tongue varies in its appearance in the early and late stages. In the early stage, when the condition is superficial, it differs but little from that of a lymphangioma. In late stages and in cases where the disease is widespread, the surface of the tongue is intersected by deep sulci and the papillæ are enlarged. Eventually the tongue becomes dry and discoloured. Extreme deformity occurs in advanced cases, the normal angle of the mandible is altered and the incisor teeth are displaced outwards. Treatment consists in removal of part of the tongue or in irradiation by means of radon seeds.

CYSTS

Mucous Cysts.

The simplest form of cyst which occurs in the mouth, lips and tongue is a *retention* cyst due to obliteration or obstruction of the duct in connection with a mucous secreting gland. They occur most commonly in the lips, and are bluish, transparent, painless, soft, or tense swellings; the wall of the cyst is very thin, the contents a clear glairy fluid. In the tongue such cysts are situated either on the lateral margin or in the vallecula; the latter may attain a big size and interfere with swallowing, or cause stertorous breathing by displacing the epiglottis

and obstructing the laryngeal opening. Cases of death from asphyxia due to simple mucous cysts are recorded.

Dermoid Cysts

The characteristic situation of a dermoid cyst in the mouth is the mid-line, anteriorly, below the tongue or in the floor of the mouth. They appear in early adult life, although congenital in origin, and are slowly progressive. A dermoid cyst by increasing in size will displace the tongue upwards and backwards and also present in the submental region. The walls are thick and opaque, the consistency characteristically dough-like. The swelling is soft and painless; unlike a lipoma it is not lobulated and sometimes pits on pressure. The cyst wall is lined with stratified squamous epithelium. These cysts originate in the median raphe of the tongue and extend downwards and backwards above the mylo-hyoid and between the two genio-hyo-glossi. They contain a fatty, pultaceous, semi-fluid material composed of cholesterin, fatty acids sebaceous material, and sometimes hair and teeth. Clinically they are recognised by their median position, the swelling in the submental region, the displacement of the tongue which retains its full range of movement, the yellowish colour and the typical consistency; speech is impaired, *and this as well as the deformity requires treatment. Treatment consists in the* removal of the cyst The operation should preferably be done through the mouth and not from the submental region Under a general anæsthetic a transverse incision is made in the floor of the mouth over the swelling; unless inflammatory adhesions due to previous incision are present. the mucous membrane of the tongue is easily stripped from the underlying cyst wall; by blunt dissection the cyst is separated from the genio hyoid and in most cases can be completely shelled out. The wound in the floor of the mouth is closed by interrupted catgut sutures without drainage Redundant mucous membrane should not be removed, as healing occurs more readily if there is no tension on the sutures; sublingual œdema which occurs after the operation subsides in a few days.

Thyroglossal Cysts and Lingual Thyroid (see also Vol. II, pages 1917 and 1936)

Thyroglossal cysts or tumours are congenital abnormalities due to the persistence of a tract leading from the foramen cæcum to the region of the hyoid. The abnormal developmental remains occur either on the surface of the tongue (lingual thyroid), inside the tongue (deep to the foramen cæcum), on the floor of the mouth (below the mucous membrane and above the hyoid bone, clinically in the submental region), or lower down in the neck. The tract may be completely obliterated, the lingual or infra-hyoid portions alone remaining, or it may persist, leading from the hyoid to the foramen cæcum or a little distance from it. The remnants may undergo hyperplasia or cystic degeneration similar to the changes which occur in the normally situated thyroid gland; or infection in the tract may supervene and lead to sinus formation. The clinical importance of abnormal thyroid remains lies in the fact that sometimes such remains constitute the only active thyroid the patient possesses and their removal has not infre-

quently led to myxœdema. The lingual thyroid is, as a rule, discovered accidentally by the patient or on a routine examination of the mouth; in most cases it forms a mass behind the V of the circumvallate papillæ; the size varies from a small nodule to an appreciable quantity of thyroid tissue large enough to give rise to symptoms. The colour is purplish-red; the mucous membrane over it is very thin and denuded of papillæ; the mass appears slightly lobulated or is multilocular, mulberry-like, and of soft consistency. Hæmorrhages may occur inside the mass, leading to temporary increase in size and alteration in colour. Periodic variations in size occur sometimes in young female patients synchronously with the periods. In the vast majority of cases the condition requires no treatment and causes no symptoms; where the symptoms are slight, active treatment, such as removal, is still contra-indicated; hæmorrhage or cystic degeneration, however, calls for treatment, and this should consist in partial removal of the lingual tumour with the diathermy loop or repeated surface coagulation with the diathermy button. Unless there is definite evidence of thyroid tissue in its normal situation, total removal of the lingual thyroid should not be undertaken for simple hyperplasia. Differential diagnosis consists in the distinction between a lingual thyroid and a mass of lymphoid tissue, or lympho-epithelioma; if there is doubt as to the nature of the swelling, biopsy is indicated. Atrophy of a lingual thyroid or diminution in size can be obtained by X-radiation, and this should be the primary method of treatment before operative measures are considered. Malignant changes in a lingual thyroid are not unknown, but they are extremely rare; adeno-carcinoma and papillary carcinoma, similar in every way to malignant changes in the normally situated gland, have been described. In such cases there is, as a rule, a long-standing history of a swelling at the back of the tongue, the malignant changes supervening later; the course of the disease and the occurrence of metastasis is typical of thyroid carcinoma. The thyroglossal tumour which occurs in the base of the tongue presents itself either as a tumour in the floor of the mouth or as a swelling under the chin. Under the tongue it must be distinguished from a dermoid or a ranula; in the submental region it may be mistaken for a lipoma. Like most pathological conditions of the thyroid, it is more common in women than in men; the swelling and its variations in size call attention to the condition; surgical treatment is only exceptionally called for if the true nature of the swelling is recognised clinically. The manifestations of aberrant thyroids in the neck and thyroglossal fistulæ are considered in Vol. II, page 1917.

CHAPTER V

Syphilis of the Mouth and Tongue (see also page 5303).

The manifestations of syphilis in the mouth, as elsewhere, present a clinical resemblance to many other oral affections. The diagnosis has been rendered easier by recognising the spirochætes in the primary lesions, by the positive Wassermann or Kahn test about the third week after the appearance of the primary lesion, and by the rapid disappearance of the manifestations following anti-syphilitic treatment. There are thus few cases to be seen nowadays such as fit the description of the older writers where confusion occurred between imperfectly treated lesions and the sequence of excessive administration of mercury.

Primary Inoculation of Syphilis in the Oral Cavity.

Inoculation of syphilis upon the lip and tongue is an exceptional occurrence and likely to be overlooked, yet it is more obvious than a chancre elsewhere because of the constant and rapid sequence of the primary sore, the enlargement of the corresponding lymphatic glands, and the rash on the chest and flexor aspects of the arms. Moreover, the *spirochæta pallida* is invariably present in the secretions from the lesion. The frequency of primary syphilis in the mouth is indicated by Fournier as follows: "Among 612 cases of extra-genital chancre, 328 occurred on the lip, and 53 on the tongue" (Fournier, *Les Chancres Extragenitaux*, Paris, 1897). The infection is a direct transmission by the saliva from mucous patches in the mouth of a case during the early secondary stage of syphilis, acquired or hereditary. The history of a previous excoriation, such as a cigarette burn on a lip or tongue, is not essential, although authenticated cases exist, as the spirochætæ may be made to pass by friction through apparently intact mucous membrane.

Chancre.

The most common site of an extra genital chancre is the lip (see fig. 2915). It is equally frequent in both sexes and occurs at all ages from infancy to old age, though the majority of cases are seen in young adults. A single lesion is the rule, but two or more primary chancres have been observed. Clinically the lesion may be ulcerative, hypertrophic, or erosive. These are merely variations due to extraneous conditions; the ulcerative type is produced by superadded pyogenic infection; the erosive variety is the commonest type; it may be small and insignificant and be completely missed clinically, being presumed to be a herpetic

Chancre of the Tongue.

The most common situation of a lingual chancre is the tip of the tongue or the dorsum immediately behind the tip. It is generally a solitary circular lesion 1-3 cms. in diameter; multiple small lesions may occur in a tongue with superficial excoriations. It is slightly raised above the surface of the tongue, excoriated, and dusky brown in colour. Surrounding the chancre is a *zone of œdema*, less marked, however, than in chancres of the lip. The clinical appearance, the subsequent *glandular enlargement and cutaneous eruption, the absence of pain*, and the indolent character of the primary lesion and of the glands should make the *clinical diagnosis relatively easy. More difficulty attends the very exceptional* inoculation of a chancre towards the back of the tongue; this is most commonly seen in women, the chancre being associated with a traumatic lesion due to a carious molar tooth or an ill-fitting denture with sharp edges. Following the appearance of a chancre in the mouth, there ensue the early manifestations of generalised syphilis.

Early Generalised Syphilis.

Syphilitic lesions appear on the lips and in the mouth during the secondary stage of the infection. These manifestations follow the appearance of the chancre by two or three weeks and may not appear till *after* the cutaneous secondary lesions have disappeared. Clinically the varieties of lesions are described as macular, erosive, papular, and ulcerative; they merge into one another and occur simultaneously, but not with equal frequency. The commonest variety is the *erosive syphilide* or *mucous patch*; the macular syphilide is often so transient as to be overlooked; the papular variety is, as a rule, confined to the dorsum of the tongue and angles of the mouth; the ulcerative secondary lesion occurs from superimposed pyogenic infection.

The erosive syphilides appear on the mucous membrane of the lip, the tip and sides of the tongue, the inner aspects of the cheeks behind the angles of the mouth, the pillars of the fauces and on the palate. Essentially they begin by the spirochætes invading the small blood-vessels of the papillæ, which become swollen to form a papule 1–2 cms. in diameter and predominantly oval. A greyish-white film of epidermis, macerated by heat and moisture, is raised and becomes covered with mucus and fur. There is no marked inflammatory areola, and the whole process, whether single or multiple, is indolent; generally the lesion is a multiple one. Under the tongue where the patches are least disturbed by the teeth or passage of food, the swelling of the papillæ is the more marked, so as to resemble a cauliflower-like papillomatous swelling, more a dead white than elsewhere, and to this the old term, condyloma, is the more applicable. Uncomplicated by oral sepsis, carious teeth, or ill-advised irritating applications, erosive syphilides cause little disturbance in mastication, and naturally have but a short existence. Soon after their appearance there follows an erythematous eruption in the fauces which may advance to ulceration of the tonsils; at the same time occur skin eruptions and the falling out of hair. The appearance of the mucous patches varies considerably, and depends largely on the part of the tongue upon which they rest. The best examples are those which occur far back on the dorsum, or on the undersurface near the tip. A typical mucous patch on the dorsum near the circumvallate papillæ is generally rounded or oval in form, and appears as a greyish-white plaque, slightly raised above the surrounding parts. It is sharply defined, yet the

border is usually not quite regular, but wavy, or it projects at irregular intervals. The oval outline is well maintained, even when the patches are of considerable size. Immediately beyond the border of the patch the tissues are normal; there is no redness or swelling, unless there is accidental contamination by pyogenic organisms. The surface of the patch is sometimes quite smooth and even, but is not unusually broken by depressed lines, cracks and fissures. After the white layer has been more or less completely removed, it leaves behind a smooth, red, slightly raised base, which is defined from the surrounding parts by its smoothness and greater redness.

On the under-surface of the tongue the patches not infrequently appear as excellent examples of condylomata, which are warty or cauliflower-like excrescences. The surface is white, and as a rule, a more dead white than that of the patches on the dorsum On the tip and borders the characters of mucous patches are often so modified that the appearances they present are very different from those which have been described There the borders are frequently sinuous or deeply notched, and immediately beyond is a bright red areola, extending for about an eighth of an inch into the surrounding natural red, with which it gradually fuses. The surface of the patch, instead of being smooth or warty, may become ulcerated or deeply grooved, or spread out and marked by vertical lines of red and white alternately, this is due to the pressure or rubbing of the teeth or stumps of teeth. The ulceration may be merely superficial or it may extend deeply into the substance of the tongue. The first appearance of the mucous patch is usually in the form of a very small and slightly raised white-grey spot, perhaps not larger than a small split pea, but it quickly enlarges, without any sign of inflammation, and, unless it be ulcerated or injured, is probably unnoticed for a time by the patient. Several patches may coalesce and in this manner some of the large and most irregularly shaped patches may be formed. The entire patch may enlarge in all its diameters so as to preserve its original oval shape; or it may spread over the adjacent surface of the tongue by irregular processes. If left untreated, mucous patches may remain very little altered for a long time, they may extend slowly, until a large part of the surface of the tongue is covered by them, or they may undergo some of the changes which have been described, may lose their white coating, or may ulcerate on account of the irritations to which they are subjected. They may heal, too, spontaneously, for many persons pass through the entire period of secondary syphilis without treatment, and all the symptoms disappear. The secretion which comes from these mucous patches and the discharge from the ulcers are contagious. In the absence of irritation, and under active treatment by mercury and arsenic, fibrosis sets in and the lesions heal. Ulceration only follows upon aggravation by oral sepsis, excessive administration of mercury, abuse of alcohol, and irritation through smoking.

Differential Diagnosis of Oral Manifestations of Secondary Syphilis.

The acute manifestations of the secondary stage of syphilis as they appear clinically in the mouth must be differentiated from the various following conditions: (1) Small multiple traumatic lesions interfered with by the patient or inadvisedly treated by silver nitrate; (2) Mercurial and arsenical stomatitis; (3) Herpetic lesions in the stage when the vesicles have ruptured and multiple small raw surfaces are present, and (4) Gingivitis and stomatitis due to acute and severe infection with Vincent's spirilli. Such lesions, however, can be recognised by the severe

symptoms (absent in syphilis), fever, marked salivation, peculiar and characteristic fœtor of the breath, and expert bacteriological examination. The enlargement of the glands is often misleading.

Late Oral Manifestations of Generalised Syphilis.

The late lesions are produced by vascular and perivascular invasion by spirochætes, ending in fibrosis and in epithelial changes, such as are seen in leukoplakia. A more extensive lesion tending to necrosis at the centre, and possibly followed by an invasion by pyogenic organisms, forms gummata—whether multiple and discrete, or massed into a tumour-like swelling. Alternatively, the gummatous stage appears as a progressive sclerosis, spreading from the epithelial surface inwards into the muscular substance, and aggravated by sources of irritation, and this sclerosis formerly produced such an enlargement of the part or of the whole of the tongue as to be called syphilitic macroglossia.

A single gumma, not superimposed upon an earlier lesion, occurs by preference in the median raphe of the tongue, where it forms an indolent swelling covered by intact mucous membranes. Near the surface it may be noticed first as being about the size of a pea.

If the gumma undergoes necrosis at the centre and breaks down, there is added pyogenic infection, and a deep ulcer or an indurated fissure forms. The lesion on the whole is so far painless, hence it may be neglected until cancer has supervened. Especially is this the case at the base of the tongue and at the junction with the pillar of the fauces.

Unbroken gummata may be quite superficial or deep (sometimes called parenchymatous). Both forms are much more frequently observed in males than in females, and may occur at any time during the period of tertiary syphilis, but on the whole are seldom observed until several years have elapsed since the inoculation of the primary disease.

The *superficial gummata* occur more frequently upon the dorsum than at the tip or borders. They form projecting nodes and nodules of various size in the mucosal and submucosal layers, and are felt as little hard bodies. They are at first quite indolent and are not noticed unless they project more than usual from the surface, or are irritated. The mucous membrane covering them is at first papillated when they occur in the papillary area ; but when they extend towards the under-surface it continues quite smooth. The colour is at first natural, later becoming redder. As a rule they are multiple, but occasionally a single superficial gumma is observed. They may remain for a long time unbroken, continuing in some patients for many weeks or months unchanged, but this is more usual in deep than in superficial gummata.

The *deep* or *parenchymatous gummata* are usually much more formidable affections, more difficult to diagnose, and much more destructive than the superficial, unless the latter are very numerous. They may occur in any part of the muscular substance of the tongue, but tend almost exclusively towards the dorsal aspect, whether they are situated near the borders or towards the middle line. They occur as often at, or near, the borders as near the middle line, although they are said to affect generally the central parts of the tongue (see fig. 2744). They attack, for the most part, men at or about the middle period of life ; but they are met with in women as well as men, and are not unknown in children, for they may result from congenital syphilis. They have even been seen in the tongues of infants,

but this is very rare. Deep gummata vary greatly in size. They may be quite small or they may attain the size of a hazel-nut, or even of a small walnut; but the very large gummatous masses are generally the result of the conglomeration of several gummata. Although they may vary thus in dimension, large size is the rule, and small (such as that of the superficial gummata) the exception. They may lie at almost any depth in the substance of the tongue, and when very deep they are scarcely appreciable to sight, as they form only a slight bulge or rounding of the dorsum. But they can be palpated as rounded or oval tumours, not very clearly defined feeling almost like a foreign body in the substance of the muscle, surrounded by a layer of inflamed tissue. They are also very indolent, producing very little or no spontaneous pain, and are not usually tender when handled. The mucous membrane covering them is unchanged, unless they are threatening to break. Such gummata may be single or multiple. Perhaps multiple gummata are rather more frequent than single gummata; and when they are multiple, the tumours

Fig. 2744.—Gumma affecting the lateral border of the tongue; the more usual situation is the dorsum.

(From Butlin's Collection.)

may be either separate and lie far apart, or may be close together. They may, as has been stated, become conglomerate, and so produce very large, irregular masses. The natural tendency of gummata, whether superficial or deep-seated, is to break down and produce ulcers; but they may remain a very long time unbroken.

The more superficial of the deep gummata project as prominent rounded masses on the surface of the tongue, almost invariably on the dorsal surface. Their characters are similar to those of the deeper tumours, but their limits are easier to define, and their hardness is more evident. The mucous membrane over them is generally smooth, and, if they are very near the surface of the papillary area, is often devoid of papillæ. But unless the tumour is softening, the colour is not usually changed.

In the progress of the disease the tumours become softer, and approach more nearly to the surface. They still retain their rounded or oval form. They enlarge, and the mucous membrane becomes smoother and redder over them, and sometimes they become tender, but very seldom actually painful before they break. Fluctuation may sometimes be plainly detected in the larger tumours.

The *diagnosis of superficial gummata* is not so difficult as that of the deep masses. They are so much more commonly multiple than single; they are often situated in parts of the surface of the tongue which are not easily irritated; they tend to

break down at an early period; and they are so frequently accompanied by other signs of syphilis that they are generally easy to recognise. A single small superficial gumma, especially if it is situated on the border of the tongue, may be more difficult to diagnose; it may be mistaken for a carcinoma in a very early stage when it has scarcely yet become a cancer and is rather in the pre-cancerous stage. If there is a rough tooth opposite the little tumour, the diagnosis can hardly be made in the absence of a history or other sign of syphilis. But the real nature will soon appear on removal of the tooth and on the administration of iodide of potassium.

The *diagnosis of deep gummata* may be so clear that it is impossible to be mistaken in it; and, on the other hand, it may be so difficult that it may be quite impossible to arrive at a correct conclusion. The two conditions which are most likely to be mistaken for gummata are innocent tumours, such as fatty and fibrous tumours, and carcinoma, especially in the early stage of the nodular variety. The innocent tumours are very often polypoid; gummata are never so. Innocent tumours are almost always clearly defined, elastic, and separate from the natural structures of the tongue; gummata are usually less sharply defined, are indolent and inelastic, and are not separate from the surrounding textures. Innocent tumours are more often single, gummata more often multiple. Innocent tumours are sometimes lobulated; gummata are never lobulated, although a false aspect of lobulation may be given to a gumma by the close proximity of two or more of them. A cancer very often forms opposite to, and as the result of the irritation of, a carious tooth; a gumma has no connection with bad teeth. A cancer is usually a disease of persons over forty years of age; a gumma is frequently observed in persons between twenty-five and thirty-five years of age. In all doubtful cases the presence of other signs of syphilis must be carefully sought for, the history of syphilis inquired for, and a Wassermann reaction carried out.

A gumma may be mistaken for a chronic abscess, but the abscess is usually more clearly defined than the gumma, and has a more distinctly rounded shape. Unless, however, there are associated signs of syphilis, it is probable that the diagnosis will not be made with any certainty without puncturing and aspirating the tumour or testing the effect of anti-syphilitic treatment.

Again, it is possible that a gumma may be mistaken for a foreign body, or, more probably, that a foreign body may be mistaken for a gumma. The history of an accident, and the long continuance of the tumour in an unaltered condition, together with the absence of history and signs of syphilis, are the conditions on which the diagnosis will depend.

Syphilitic Destruction of the Palate.

A gummatous ulceration attacks the soft palate and advances by a serpiginous ulceration to cause a very obvious deformity. The soft palate may ulcerate along with an ulceration of the posterior wall of the pharynx. Later, adhesion follows, blocking the naso-pharyngeal airway, involving the necessity for mouth-breathing, and also blocking the orifices of the Eustachian tubes—resulting in aural inflammation and deafness.

The gummata may form at the hinder part of the hard palate and quickly perforate into the nose. There are then set up two obvious and persistent deformities: regurgitation of food into the nose, and a nasal twang to the voice.

A gummatous ulceration, aided by pyogenic organisms, may rapidly destroy the whole of the palate, both hard and soft.

Perforating Ulcer of the Mouth.

Fournier gave the name of "*Mal perforant buccal*" to a syndrome accompanying locomotor ataxia in three phases: (1) an absolutely painless and otherwise spontaneous falling out of teeth which were previously sound and unaffected by caries; (2) an insidious absorption of the alveolar border of the maxilla—so far these do not differ from changes seen in old age, but (3) after a variable length of time a painless ulceration and sequestration, without hæmorrhage, occur with perforation into the maxillary antrum. Fournier described the syndrome in a case in which the cranial nerves had not yet become involved.

Treatment.

The treatment of syphilitic lesions of the mouth and tongue is essentially the same as that of syphilitic lesions elsewhere (see page 5317). Oral hygiene is of great importance, and sepsis and caries must be attended to, as otherwise effective treatment is not well tolerated. To the time-honoured treatment by mercury is now added that by bismuth, which is equally effective and less likely to produce or aggravate stomatitis. Bismuth compounds such as bismuthyl and bisoxyl are given intramuscularly and are very effective anti-syphilitic remedies, especially in tertiary lesions, 0·3 to 0·4 gm being given at weekly intervals for ten to fifteen weeks.

Of the arsenical compounds, those of the salvarsan group ("606") are now rarely used, their place being taken by the "914" group or neosalvarsan; of these stabilarsan is perhaps the least toxic and is very efficacious. It can be given intramuscularly in doses varying from 0·45 to 0·75 gm. at weekly intervals continued for ten to fifteen weeks. A pentivalent organic arsenical compound —acetylarsan—is available as an excellent substitute for the trivalent group compounds; it is a very effective anti-syphilitic remedy, and can be given intravenously, subcutaneously, or intramuscularly in doses of 1 to 5 cc. It is non-toxic and is rapidly eliminated, chiefly in the urine. It is given twice weekly.

CHAPTER VI

Tuberculosis of the Mouth and Tongue

The tongue and the buccal mucous membrane are resistant to infection by the tubercle bacillus, and the disease in this situation is therefore comparatively rare. The majority of cases are *secondary* lesions to tuberculosis of the respiratory tract. *Primary* tuberculosis of the tongue has been recorded with certainty in only a very small number of cases. Of a total number of about 25,000 post-mortem examinations on cases of tuberculosis recorded by nine different authors only 86 cases or 0·34 per cent were found to have tuberculous disease of the tongue. The method of infection according to Handfield-Jones (*Lancet*, 1923, I, 8–11) may occur: (1) by direct inoculation; (2) from tuberculous sputum; (3) by the blood stream; (4) by the lymphatic path; or (5) by direct spread from neighbouring structures.

The most common sites for tuberculous lesions in the mouth are the tip of the tongue on the lingual frenum, the soft palate, the uvula, the mid-line of the hard palate, the tonsils, and the epiglottis. The types of lesion—miliary, fissure, abscess, ulcer, lupus, papilloma, and tuberculoma—can be conveniently grouped into *three* clinical types: (1) *lupus vulgaris*; (2) *the tuberculous ulcer*; and (3) *the tuberculoma*.

Lupus Vulgaris.

The intra-oral lesions of lupus vulgaris generally accompany similar lesions of the skin, and in most cases are direct extensions from skin to the mucous membrane of the lips and mouth. The early lesions are small, red, soft, rounded nodules presenting on pressure with a glass slide the typical "apple jelly" appearance. A dark red swelling of the mucous membrane precedes and accompanies the development of the nodules; later, small pale granulations appear which bleed on slight trauma. The multiple small lesions enlarge and coalesce; superficial ulceration follows and the surface becomes covered by a grey film formed by mucous and purulent discharge. Lupus of the mucous membrane may heal in one part whilst breaking out in another. The scar is thin and parchment-like and readily breaks down. It occurs chiefly in young women and is the least serious as regards prognosis.

Tuberculous Ulcers.

A tuberculous ulcer chiefly affects the tongue and the lips but is occasionally seen on the uvula, the buccal mucosa and the gums. It is a disease of the adult already affected by pulmonary or laryngeal tuberculosis. Various clinical types of tuberculous ulcers occur in the mouth. The *simple* tuberculous ulcer is generally found on the tongue or the floor of the mouth, and occasionally on the lips. It starts as a nodule which may be single or multiple, and which rapidly breaks down; it is oval in shape, dark in colour, with a soft base covered with pale granulations; the edges are levelled or sometimes undermined. In the immediate vicinity of the ulcer can be seen small greyish-yellow spots which eventually break down and form new ulcers. As the disease advances, the ulcer, at first superficial, becomes deeper. The lesion is exquisitely tender and painful, and salivation is markedly increased.

Tuberculous ulcer occurs more frequently in men than in women. Although no age is exempt, it occurs chiefly in adults. It is a progressive lesion which becomes more and more painful as its depth and width increase. Superficial ulcers occasionally heal with a thin scar which is apt to break down. The diagnosis of a tuberculous ulcer presents at times considerable difficulty. It can be distinguished from syphilis by its painful character, the lack of induration of the base, and the undermined or bevelled edge. It can be distinguished from cancer by the presence of small satellite lesions in the vicinity of the main ulcer, by the pallor of the granulations lining the base, and by the sodden condition of the surrounding tissue. The *history, blood tests, bacteriological examination,* and histological features of the lesion will, in the end, determine the correct diagnosis.

Tuberculoma.

The *nodular and fissured* type occurs at the sides and tip of the tongue; the lesion is stellate and generally single; the margin is indurated, and the fissure, when drawn apart, shows it to be a deep but narrow ulcer. It may extend into the muscular layer of the tongue without corresponding surface extension. Such lesions have been described as tuberculous rhagades. The *papillomatous* type is the fissured variety with papillomatous granulations on the edges of the fissure; the granulations appear to be covered with thinned epithelium. The lesion is the rarest type met with and is the least painful.

The prognosis of tuberculosis of the tongue and mouth is very grave. With the exception of the lupoid variety, it must be considered as a terminal phenomenon in a patient infected with active and virulent pulmonary tuberculosis, whose resistance to the disease has broken down. Healing of such ulcers does occur, but is not as a rule permanent. The ultimate prognosis depends upon the pulmonary and not the intra-oral lesion.

Treatment

Like all tuberculous lesions, a tuberculous tongue should be regarded as a local manifestation of a generalised infection. Each case must be treated on its own merits. Surgical treatment is chiefly dictated for the relief of pain. If the general condition of the patient permits it, if the lesion in the mouth is localised, and if the symptoms produced by it are severe, removal of the ulcer must be attempted. Simple excision and suture hardly ever succeed, as the freshly cut surfaces are quickly re-infected either by the sputum or from the ulcer itself. Diathermy fulguration, surface coagulation or excision is the safer and more efficient method. The lesion can be destroyed or excised, but in neither case is it advisable to attempt to suture the raw surface. If any form of excision is precluded, radiation therapy with ultra-violet rays should be tried. The Krohmeyer lamp is a convenient method of applying ultra-violet radiation; it has the advantage of being accurate, and its rays can be localised to very small areas. As the mucous membrane of the mouth is much more sensitive to radiation than the skin, great caution in treatment is essential and each treatment should be of very short duration. The superficial tuberculous ulcer is the most likely to benefit from treatment; papillomatous, nodular or fissured types are more suitable for diathermy. In all cases, oral hygiene, dental cleanliness, and general treatment of the patient are of equal or even greater importance. The local treatment must always be considered as a palliative measure and, as such, extensive surgical procedures are entirely contra-indicated.

CHAPTER VII

Leukoplakia and Chronic Ulcers of the Tongue

LEUKOPLAKIA

Leukoplakia is the commonest form of chronic superficial glossitis. It can be defined as a chronic inflammatory process affecting the mucous membrane of the mouth and tongue, characterised by the development of irregular, pearly white patches of keratinised epithelium ultimately tending to undergo malignant changes.

Ætiology.

The cause of leukoplakia is unknown. Predisposing causes commonly believed to be responsible for the development of the disease are syphilis, alcohol and dental sepsis. It is, however, quite obvious that leukoplakia develops in patients who are free from any luetic infection, acquired or hereditary, that it occurs in non-smokers and total abstainers, and also in patients with healthy teeth or edentulous mouths. It must therefore be admitted that the commonly accepted causes of chronic superficial glossitis are *secondary causes* influencing the frequency or the degree of the condition but not actually responsible for it. That the disease occurs not infrequently in several members of a family or has been known to be present in several generations of one family leads to the conclusion that the primary cause is a peculiar susceptibility of the mucous membrane of the mouth to undergo certain degenerative changes. Such an explanation may not throw much light on the origin or cause of the condition but at least it frees some patients from the accepted stigma that leukoplakia is inevitably due to syphilis, alcohol or smoking. There is, nevertheless, no doubt that these conditions tend to precipitate the development of leukoplakia in susceptible patients where the inherent tendency is present. The commonest age is between the fifth and sixth decade for the fully established lesion; minor manifestations occur much earlier, in the third decade; not infrequently cases are seen in the twenties, and authenticated cases occurring between the ages of fifteen and twenty have been described. It is a disease of men although women are not exempt, even young women in the early twenties. Of the predisposing causes " smoking " perhaps more than " tobacco " is the cause of the " smoker's patch "

which eventually develops into leukoplakia. In some cases the condition is apparently caused by vulcanised dentures, and this may be due to an idiosyncrasy peculiar to the patient or more likely to lack of cleanliness of the denture. Irritation by amalgam fillings may cause patches of leukoplakia in the mucous membrane, both buccal and lingual, adjacent to the filling. Early removal of the offending filling leads to rapid disappearance of the patches. *Syphilis* is a predisposing factor in the causation of the disease, but the accepted formula of syphilis+alcohol =leukoplakia is not supported by clinical evidence.

Clinical Types of Leukoplakia.

The various types of leukoplakia may be only the stages of one and the same variety. Three types are seen clinically: (1) The *network* type. This is of tessellated appearance: linear bluish-white lesions occur on the sides of the tongue or buccal mucosa; they branch and join, and are slightly sunk below the surface of the tongue; they may be transient or permanent. The lesion is entirely symptomless. (2) The *white* patch: this type may be single or multiple, small or extensive; it is mostly oval in shape, mother-of-pearl in colour, smooth and denuded of papillæ: when the tongue is dried with a square of linen, the patch stands out clearly with definite margins; it may be slightly depressed from the general surface of the tongue as if pulled inwards by fibrosis, or may form a slight elevation on the surface. It may remain stationary for many years and then become active and spread on the surface. (3) The *warty* type is the result of some change in the simple *white* patch; it is characterised by a roughened overgrowth of the corneous layers of the papillæ, which raises the patch above the surface of the surrounding mucous membrane and gives it a papillomatous appearance; it is rough and horny to the touch. In this stage leukoplakia is quite definitely pre-cancerous and more often than not leads to malignant changes. It can be considered as one of the best instances of pre-cancerous manifestations.

Symptoms.

Most early cases, the simple flat patches and the tessellated lesions cause no symptoms. They may give rise to anxiety but not to discomfort. The warty type causes discomfort, sometimes smarting, and occasionally pain, when the lesion on the buccal mucosa is inadvertently bitten or one on the tongue is continuously rubbed against the teeth. The absence of symptoms accounts for the very long histories that such patients have and for their delay in seeking advice.

Treatment.

I have reached the conclusion that the time-honoured advice

"abstain from smoking and alcohol" is of doubtful value. Naturally, excessive smoking, especially a pipe with a short stem, and abuse of spirits are detrimental; apparently, light wines and beer in moderation have no great influence on the progress of the disease, and to forbid them in all cases is to cause unnecessary hardship without corresponding benefit. Local applications are of no value at all; potassium chlorate lozenges and mild chromic acid paints have no effects on the established lesion; strong antiseptic mouth-washes of silver nitrate or copper sulphate aggravate the condition and sometimes precipitate the onset of malignant changes. Patches of leukoplakia should be left alone in preference to inefficient, irrational, and protracted local treatment. Surgical treatment is indicated in *single circumscribed* lesions of the tongue. The work of Cramer on prophylactic irradiation of pre-cancerous conditions has shown that experimentally a pre-cancerous condition can be prevented from developing into cancer by adequate radium radiation. The author has successfully applied Cramer's principles to the radiation of leukoplakia. Patches on the tongue and buccal mucosa can be made to disappear by *efficient* radium application or contact unscreened X-radiation. The treatment must be continued to the degree of peeling of the mucosa and the formation of a white film; the patches of leukoplakia can be made to disappear and the mucosa to resume a normal smooth and healthy appearance.

CHRONIC ULCERS OF THE TONGUE

Ulceration of the tongue is not a separate entity but a further stage of various pathological conditions. A rational classification of ulcers is based upon the cause which produced them.

Simple Ulcers.

This type of ulceration occurs in some cases of long-standing chronic superficial glossitis where the tongue is devoid of papillæ and is covered with a thin pellicle forming a continuous layer broken here and there by fine lines and fissures. These tend to form in the centre of the tongue or of the diseased area, chiefly because of the lowered local resistance to infection. The ulcer may be of rapid onset (acute) due to actual sloughing of a small fragment of the surface, or it may develop insidiously by simple shedding of the epithelium covering the surface. In either case the lesion loses its active appearance at an early stage, and becomes an indolent chronic ulcer which has a smooth, red, glazed surface, inactive callous edges, is only very slightly inflamed, and not indurated. It is often sensitive, and, as a rule, painful when hot drinks

or spiced and irritating food is taken. In the "glazed" variety of chronic superficial glossitis, the ulcers are so superficial as to be merely excoriations—they are more obvious when the tongue is dried with a piece of linen.

Treatment consists in local applications of chromic acid (5 or 10 grs. to the ounce), salicylic acid (2 grs. to the ounce) or lactic acid (5 grs. to the ounce), applied regularly night and morning. For pain local application of anæsthesin powder is the best remedy. *Silver nitrate, copper sulphate, or any caustic must never be used.* Iodides and mercury are contra-indicated even in the presence of a positive Wassermann reaction: they increase salivation and discomfort and do not appear to benefit the patient. Unless rapid healing takes place, excision should not be delayed. Incisions are made round the ulcer about ¼-inch from the edge: the cut must penetrate deep into the substance of the tongue, so that a considerable depth of muscular tissue is removed, and there is no tension on the edges of the wound; when these are brought together with catgut sutures, accurate suturing will achieve complete hæmostasis. Stitches must be removed early (not later than the third or fourth day) to prevent fresh ulceration at the site of the needle punctures.

Dyspeptic Ulcers

Under this heading are described simple ulcers which occur chiefly near the tip, on the dorsum, and sometimes on the under-surface of the tongue. The tongue (dyspeptic tongue) is for a greater or lesser extent red and almost raw and beefy. The filiform papillæ are absent, and consequently the fungiform papillæ appear larger and more prominent than normal. The rest of the tongue, especially the posterior part, is thickly coated with fur. Small superficial ulcers are present, more often than not circular but presenting no special characteristics; besides definite ulceration there are also areas of superficial excoriation. These lesions are sometimes found in children and youths, but most frequently in adults suffering from dyspepsia, those indulging in excessive eating and drinking, and in invalids enfeebled by disease. It is thought by some that idiosyncrasy to certain articles of diet may be responsible for the condition.

Active treatment is not indicated. Attention to diet and bowels is all that is needed in most cases. Locally, alum in a weak solution, or a chlorate of potash mouth-wash is indicated.

Herpetic Ulcers.

This type of ulcer is met with in children from the age of six months

to three years, and also in adults. They may be prodromal to or concomitant with certain of the exanthemata, or may appear without any apparent cause, accompanied by slight fever, malaise, loss of appetite, and constipation. The mouth is hot and dry, salivation is increased, and the breath is almost invariably fœtid. On examination, the mucous membrane is livid or deep red, and small vesicles are present near the tip and on the surface of the tongue, and on the inside of the lips and cheeks. The vesicles are only a transient stage, and they soon burst, leaving behind them ulcers, which are small, round or oval, superficial, with sharp-cut edges, and at the base a yellowish-white adherent slough surrounded by a bright areola. The crop of vesicles varies in number, but there are rarely more than twenty; usually the ulcers heal rapidly, but it is not an uncommon occurrence for fresh crops of vesicles to appear every few days for several weeks. In such cases vesicles and ulcers are present simultaneously in the same patient. After separation of the slough, the shallow ulcer heals and leaves behind neither scar nor stain.

Diagnosis is usually easy; the malaise, the fœtid breath, the presence of vesicles, and the appearance of the ulcers are very characteristic of the disease.

Treatment consists in the administration of saline aperients, regulation of diet, local application of borax and glycerine, mild mouthwashes, and the administration of radiostoleum, halibut-liver oil and iron. Mercury must on no account be given.

Traumatic Ulcers.

Chronic ulceration may be set up by a wound, whether caused by a cutting instrument, gunshot, or definite bite by a tooth.

More obscure in origin, a chronic ulceration may result from the continuous irritation of a rough jagged and carious tooth, or by a badly-fitting denture having a rough surface. Those upon the frenum of children arise from contact with the sharp edge of lower median temporary incisors in the course of whooping-cough and in Riga's disease.

Dental ulcerations, however obscure in origin, are restricted to the tip and border of the tongue, and vary from mere excoriations or cracks in the mucous membrane to ulcers 1–3 cms. in length, but are seldom at all deep; the surrounding tongue becomes, in fact, raised by œdema when a jagged tooth presses directly into the ulceration. The ulcer is generally single, and the dorsum of the tongue free from ulceration. The tongue becomes furred and the breath malodorous, rather from decomposition of the fur and the presence of pyorrhœa than from any discharge from the ulcers.

Treatment of a chronic traumatic ulcer demands the consideration of two recommendations:

(1) *Dental.* In the simplest case, filing down of any projection and scaling of the surfaces of the teeth, with general care to remove oral sepsis, may suffice; the ulcer afterwards heals, followed by a cicatrix free from previous inflammation. But when the ulcer is obviously due to a tooth which cannot be prevented from impinging on the ulcer, extraction of the offending tooth is obviously necessary. The ulcer will then heal unless prevented from doing so by the tongue being sucked into the gap left by the extraction. But when more than one tooth is carious, there are evidences of pyorrhœa alveolaris, and an X-ray photograph discloses signs of apical disease, then more extensive extraction is called for. If the ulcer, even although there is no longer actual contact with a tooth, does not heal owing to the persistence of oral sepsis, new dentures, well-fitting and having smooth surfaces, may be required.

(2) *Pathological.* The more chronic the ulcers and the more indurated the margins, base and surroundings of the ulcer, the *greater the probability of epithelioma supervening. The removal of a* small piece for microscopical examination is not a satisfactory procedure. The portion removed may exhibit only chronic inflammation, and the patient may then refuse further excision. The proper course is to advise an excision of the whole ulcer followed by suture, as already described. The ulcer so removed should be thoroughly examined by making serial sections, for, whereas part of the ulcer may be found to be still in the stage of chronic inflammation, at some part commencing epithelioma may be disclosed.

ACKNOWLEDGMENT

I would like to express my great indebtedness to Messrs. H. K. Lewis & Co., Ltd., the publishers of the 3rd Edition of Butlin's *Diseases of the Tongue*, by Mr. W. G. Spencer and myself, for their kind permission to use eight illustrations, already acknowledged in the text, and also some of the material of the book reproduced in this article.—STANFORD CADE.

PART XXXI

ŒSOPHAGUS AND DIAPHRAGM

by

LAURENCE O'SHAUGHNESSY

SECTION 1

ŒSOPHAGUS

SECTION 2

DIAPHRAGM

SECTION 1

ŒSOPHAGUS

HISTORICAL

GRAVE difficulty has always attended surgical intervention on the œsophagus and, although John Hunter made an ingenious appliance from an eel skin to treat what was probably a case of cardiospasm, for the most part œsophageal surgery was not attempted until comparatively recent times.

The introduction of radiology and endoscopy towards the end of the last century made possible the exact diagnosis of œsophageal disease, and the development of surgery of the œsophagus began. It was soon proved impossible to make the rapid progress which had followed the application of Lister's principles to abdominal surgery. Apart from the technical difficulties of surgical exposure of the œsophagus, the absence of a serous coat denied to œsophageal resection the success which so soon attended resection of the stomach and intestines, and leakage from a defective anastomosis into the loose cellular tissues of the mediastinum was a more serious event than a similar accident in the abdomen, where the localised defensive action of the omentum and peritoneum will often prevent disaster.

In 1904 *Enderlen* made the first successful exploration of the œsophagus by the mediastinal route, and in the same year successful transpleural resection of that organ in a dog was carried out by *Sauerbruch*. *Heidenhain* and *Meyer* were among those who made early contributions to the subject.

In 1894 *Bircher* attempted a planned œsophagoplasty, using a long skin tube—a method which *von Häcker* had successfully employed for replacement of the cervical œsophagus. The use of a jejunal loop was first tried by *Wullstein*; *Roux* modified and improved the technique; and the first successful case was done by *Herzen* some years later.

Œsophago-gastrostomy was first successfully carried out by *Heyrovsky*, using the abdominal route, while *Henschen* recorded the first successful case by the transpleural route.

The number of successful interventions for carcinoma of the œsophagus remains small. As early as 1913 Sauerbruch extirpated a

trunk. The right vagus reaches the œsophagus at the level of the fifth dorsal vertebra, the left vagus at the level of the eighth dorsal vertebra, and the ramification of these two nerves forms the œsophageal plexus. This plexus is connected

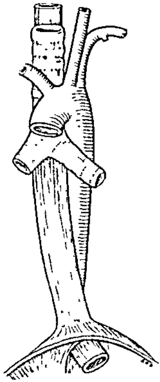

Fig 2745.—The œsophagus. (After Torek. "Nelson's Surgery")

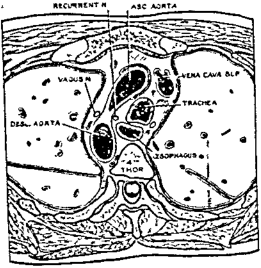

Fig 2746.—Transverse section of the thorax at the level of the fourth thoracic vertebra.

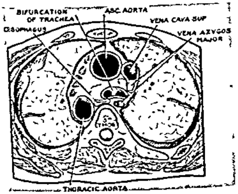

Fig. 2747.—Transverse section of the thorax at the level of the fifth thoracic vertebra.

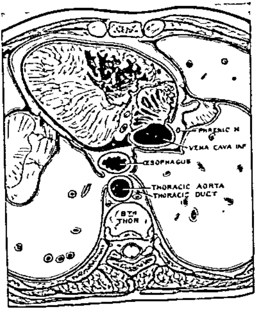

Fig 2748.—Transverse section of the thorax at the level of the eighth thoracic vertebra. ("British Journal of Surgery")

to the bronchial plexus by many fine branches. Sympathetic fibres reach the œsophagus above from the first dorsal ganglion, travelling with the vagus stem, while below direct branches reach the plexus from the dorsal sympathetic chain. A nervous plexus lies between the two muscular layers (plexus myentericus).

carcinoma of the upper thoracic œsophagus, making his approach from the neck. *Torek*, in the same year, resected the entire œsophagus together with a carcinoma which was at the level of the aortic arch. *Lilienthal's* case of resection of a carcinoma by the mediastinal route and restoration of the canal *in situ* by means of a plastic operation remains unique, although *Grey Turner* has more recently carried out an anterior thoracic œsophagoplasty after removal of the œsophagus for carcinoma and *Gohrbrandt* has excised a carcinoma of the abdominal œsophagus and restored continuity.

ANATOMY

The œsophagus is a muscular canal, 23 to 26 cms. in length, leading from the pharynx to the stomach It is composed of three coats—mucous, submucous, and muscular The mucous coat is composed of stratified squamous epithelium which rests on a very loose submucous coat. Unskilful instrumentation of the œsophagus may lead to great injury, as once the epithelium is perforated the instrument meets with little resistance in this loose tissue. The muscular coat has an outer longitudinal layer and an inner circular layer and is composed of unstriated muscle throughout. It is not uncommon to find a bundle of muscular fibres arising from the diaphragm and encircling in sphincter fashion the lower end of the œsophagus as it passes through the hiatus œsophagi.

The distance from the incisor teeth to the cardiac orifice is at least 37 cms., so that 50 cms is a suitable length for a bougie. The cervical portion, which begins behind the cricoid cartilage at the level of the sixth cervical vertebra, has a length of 7–8 cms , the thoracic portion a length of 16–18 cms., and the abdominal portion a length of 1–3 cms. Traction on the stomach may expose as much as 6 cms of the œsophagus, but as a consequence of this manœuvre reflex disturbance has been described.

The important relations of the thoracic œsophagus are as follows: the trachea, left bronchus, aorta and pericardium form anterior relations; the œsophagus lies on the bodies of the vertebræ; and on each side are the pleuræ (figs. 2745, 2746, 2747 and 2748).

The *arterial supply* of the œsophagus in the upper portion springs from the inferior thyroid artery; in the upper thoracic region, branches from the bronchial arteries and the upper five intercostal arteries give irregular branches to the œsophagus. The main blood supply to the lower portion comes from a single branch of the aorta, which arises at the level of the 8th rib, and on reaching the œsophagus divides into ascending and descending branches which ramify in a plexiform manner. The comparatively poor blood supply of the lower third of the œsophagus is of obvious surgical importance.

The *venous return* from the œsophagus drains into the inferior thyroid, azygos and hemiazygos veins.

The lymphatics of the œsophagus in its upper third drain into the deep cervical glands, in its middle third into the bronchial and mediastinal glands, and in its lower third into the glands lying along the lesser curvature of the stomach.

The *nerve supply* of the œsophagus is from both vagi and the sympathetic

trunk. The right vagus reaches the œsophagus at the level of the fifth dorsal vertebra, the left vagus at the level of the eighth dorsal vertebra, and the ramification of these two nerves forms the œsophageal plexus. This plexus is connected

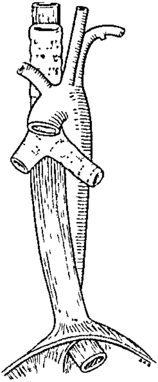

Fig 2745.—The œsophagus. (*After Torek, "Nelson's Surgery."*)

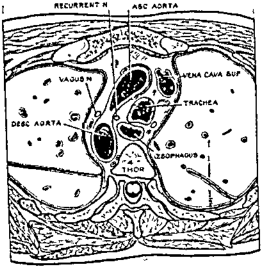

Fig 2746.—Transverse section of the thorax at the level of the fourth thoracic vertebra.

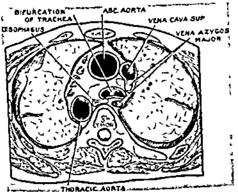

Fig. 2747.—Transverse section of the thorax at the level of the fifth thoracic vertebra.

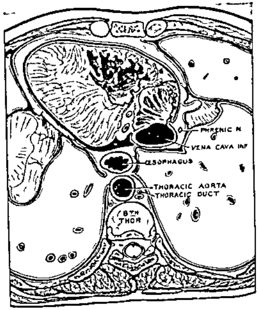

Fig 2748.—Transverse section of the thorax at the level of the eighth thoracic vertebra. ("*British Journal of Surgery*")

to the bronchial plexus by many fine branches. Sympathetic fibres reach the œsophagus above from the first dorsal ganglion, travelling with the vagus stem, while below direct branches reach the plexus from the dorsal sympathetic chain. A nervous plexus lies between the two muscular layers (plexus myentericus).

PHYSIOLOGY

The gross mechanism of deglutition seems fairly clear—a solid bolus, having reached the œsophagus, is propelled towards the stomach by peristaltic waves, while fluids reach the same goal by means of gravity. The nervous mechanism which makes possible the associated reactions—arrest of respiration, and guarding of the naso-pharynx and larynx—is not so clear. Greving reasserts the old teaching of Mosso that only by means of a special centre can the activity of hypoglossal, trigeminal vagus and glosso-pharyngeal nerves be co-ordinated. He lays special stress on the importance of the intra-mural nerve plexus which, although under the control of both vagus and sympathetic, possesses considerable independent activity Section of the vagi in the neck leads to a temporary spasm of the lower third of the œsophagus, but in a few days normal function returns.

Three factors ensure the separation of the lumen of the stomach from that of the œsophagus—an intrinsic sphincter muscle, fibres from the diaphragm which encircle the œsophagus, and a valvular mechanism which comes into special prominence when the stomach is distended.

The intrinsic sphincter is the most important of these factors, although it is merely an undifferentiated part of the circular muscle coat. Sauerbruch, in his experiments on dogs, was able to demonstrate the rhythmic narrowing of the œsophagus at its lower end, which was abolished by section of the phrenic nerve. He also showed that relaxation of the sphincter took place when a sound was passed down the œsophagus once the *instrument had passed below the level of the* hilus of the lung After extirpation of the diaphragm, closure of the cardiac orifice still persisted and it was only abolished when an incision was made down to the mucosa The control of this sphincter, which is a part of the circular muscle coat of the œsophagus, is from the vagus. Gottstein and Starck showed that the fibres concerned entered the œsophagus from the main vagus stem above the œsophageal plexus, and ran in the wall to the cardia. This finding was confirmed by Sauerbruch.

The valve closure of the orifice was first described by von Mikulicz—it is formed by the mucosa of the stomach under the constant intra-gastric pressure, which is about 4 mm. Hg. Deglutition provides a pressure greater than this in the lower end of the œsophagus, which, in association with relaxation of the muscular coat, permits ingress to the stomach.

METHODS OF CLINICAL EXAMINATION

A careful *anamnesis* may often assist in the correct diagnosis of œsophageal disease. A history of old luetic infection is of special importance, while in other cases there may have been trauma or ingestion of a foreign body. In the early stages of cardiospasm the patient experiences characteristic sensations during swallowing and will often describe how temporary relief follows self-induced "vomiting," when the contents of the dilated tube are evacuated. The victim of a diverticulum may sometimes identify some individual food—grains of rice, for example—swallowed at a meal some days previously and brought

up in an attack of vomiting. In the early case of carcinoma of the œsophagus there appear to be few subjective symptoms; the patient will only complain of difficulty in swallowing when the growth is well established. A history of bleeding from the œsophagus or the bringing up of blood-stained mucus is sometimes obtained in cases of ulceration of the œsophagus, and the clinical history of peptic ulceration is discussed subsequently.

Inspection plays an unimportant role in the diagnosis of disease of the thoracic œsophagus. A large pharyngeal pouch may present as an obvious tumour in the neck.

Palpation may reveal the presence of an impacted foreign body in the thoracic inlet, and palpation of the neck will also demonstrate a spreading mediastinal emphysema of mechanical or infective origin.

Auscultation is occasionally of service. The patient is given a drink of water, and direct auscultation is practised at a point a little to the left of the 8th dorsal vertebra. After an interval of six or seven seconds a characteristic gurgle may be heard as the fluid enters the stomach.

Sounding of the œsophagus is only to be employed with caution, and modern methods of radiological and endoscopic examination have largely superseded it. In all cases the common extrinsic causes of œsophageal obstruction—tumour or aneurysm—are to be excluded; perforation of an aortic aneurysm is a possible accident.

The most convenient instrument is the English gum elastic œsophageal bougie as used in the treatment of stricture, and by means of a graduated bougie of this kind it is at least possible to detect the level of an œsophageal obstruction, although naturally its type and extent cannot be estimated.

Endoscopic examination of the œsophagus is an almost essential preliminary to any projected surgical intervention. The method is of special importance when malignant disease is suspected. The technique of the method and the endoscopic appearances of the various types of œsophageal disease are described in another section (see page 4820).

Radiological examination is essential in all cases, and both fluoroscopy and photography should be employed.

The particular radio-opaque emulsion to be employed is a matter of individual preference, but the use of a gelatine capsule containing the medium is generally unsatisfactory for, especially in nervous individuals, a localised spasm may arrest such a capsule and a false diagnosis of organic stricture be suggested. If the presence of an

œsophago-bronchial fistula is suspected, only a small amount of emulsion should be given at a time; suffocation has occurred after the sudden aspiration of a quantity of contrast medium into the bronchial tree.

Fluoroscopy permits œsophageal peristalsis to be observed, delay in normal swallowing time to be estimated, and localised spasmodic contraction to be diagnosed. At the same time the presence of any extrinsic cause of œsophageal obstruction is excluded. For the localisation of an impacted body or the detection of the site and relations of a neoplasm, careful study of a series of films must supplement the screen

Fig. 2749.—Skiagram showing œsophago-bronchial fistula. (*Lambeth Hospital.*)

examination. Fluoroscopy of the œsophagus is best carried out with the patient in the first oblique position, in order to avoid the heart shadow.

Despite the importance of radiological examination, its use must not lead to neglect of the other methods of clinical examination. In this way may arise such errors as confusion between a calcified lymph gland in the mediastinum and a foreign body, or between a deep-seated diverticulum and a generalised dilatation of the tube.

Figure 2749 is a skiagram of an œsophago-bronchial fistula, whilst figure 2750 shows the more important stages of an operation performed for the repair of such a fistula.

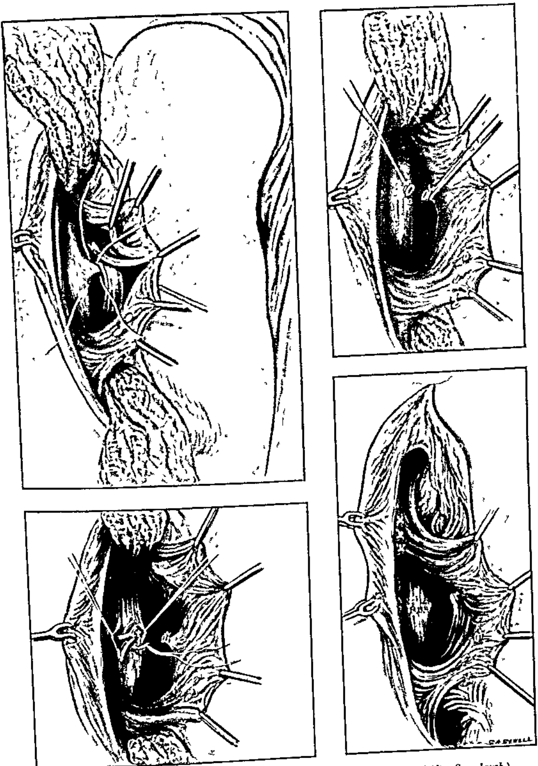

Fig. 2750.—Œsophago bronchial fistula Stages of operative repair. (*After Sauerbruch.*)

œsophago-bronchial fistula is suspected, only a small amount of emulsion should be given at a time; *suffocation has occurred after the sudden aspiration of a quantity of contrast medium into the bronchial tree.*

Fluoroscopy permits œsophageal peristalsis to be observed, delay in normal swallowing time to be estimated, and localised spasmodic contraction to be diagnosed. At the same time the presence of any extrinsic cause of œsophageal obstruction is excluded. For the localisation of an impacted body or the detection of the site and relations of a neoplasm, careful study of a series of films must supplement the screen

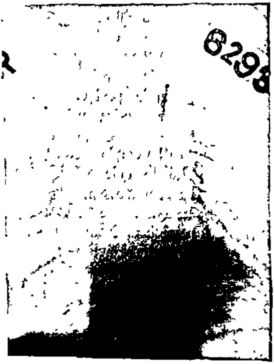

Fig. 2749.—Skiagram showing œsophago-bronchial fistula. (*Lambeth Hospital.*)

examination. Fluoroscopy of the œsophagus is best carried out with the patient in the first oblique position, in order to avoid the heart shadow.

Despite the importance of radiological examination, its use must not lead to neglect of the other methods of clinical examination. In this way may arise such errors as confusion between a calcified lymph gland in the mediastinum and a foreign body, or between a deep-seated diverticulum and a generalised dilatation of the tube.

Figure 2749 is a skiagram of an œsophago-bronchial fistula, whilst figure 2750 shows the more important stages of an operation performed for the repair of such a fistula.

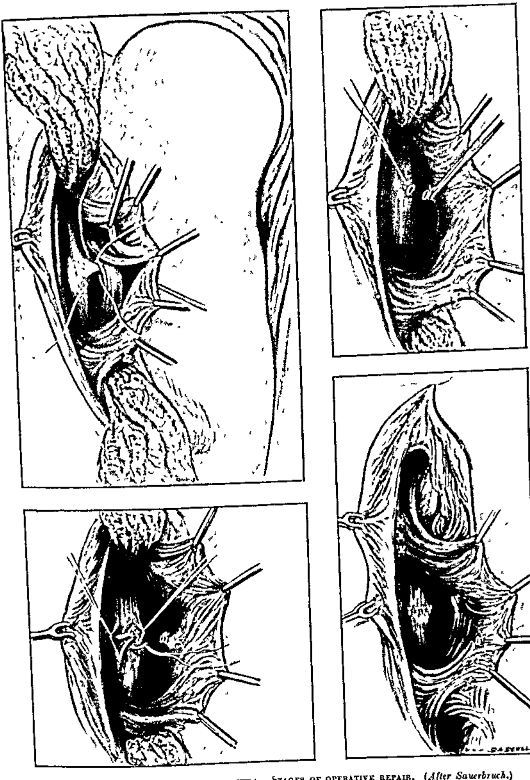

Fig 2750 —Œsophago-bronchial fistula. Stages of operative repair. (*After Sauerbruch.*)

have combined gastrostomy with occlusion of the terminal portion of the œsophagus, and recommend that the upper blind sac should be drained by establishing a cervical œsophagostomy.

There are, however, certain other congenital defects of the œsophagus which are of practical importance and deserve further consideration. These are:

(1) Congenital stricture;
(2) Membranous obstruction;
(3) Mega-œsophagus;
(4) Short œsophagus.

(1) *Congenital Stricture* (fig. 2751).

There is a history of dysphagia from earliest infancy, although acute symptoms may not appear till adult life. Some of the recorded cases have first attended for treatment at the age of thirty or over.

The stricture is usually placed in the lower third of the œsophagus and is readily diagnosed by radiology. Endoscopy reveals a normal mucous lining at the site of obstruction.

The *treatment* is dilatation by sounds, preferably under endoscopic control, and cure is more rapidly attained than in the case of acquired stricture. Unless some complication has supervened, any plastic operation should be superfluous.

(2) *Membranous Obstruction.*

Obstruction of the œsophageal lumen by a thin membrane is most common in the lower third of the tube. Total obstruction is recognised in the earliest days of life, as there is complete inability to swallow, but the membrane may be incomplete and allow the passage of fluids so that the condition is not apparent until attempts are made to swallow solid food.

The *treatment* is division of the membrane by endoscopic means, but in the absence of special apparatus the passing of an œsophageal sound will usually suffice to rupture the membrane. The clinical factors of membranous obstruction of the œsophagus are well illustrated by the following case history from Lawrence Abel.

CASE OF COMPLETE MEMBRANOUS DIAPHRAGM

The patient was a female child, who was born on the evening of January 18, 1928. The mother was a primipara and the labour, which was not abnormal in any way, lasted twenty-one hours. The child weighed 7¾ lb. and appeared to be perfectly healthy.

Throughout the whole of the following day attempts were made to feed the child at regular intervals. At no time would she suckle the breast; when given teaspoonfuls of milk and water she appeared to have great difficulty in

MALFORMATIONS OF THE ŒSOPHAGUS

Very complete accounts of the more complicated examples of maldevelopment of the œsophagus may be found in the writings of Mackenzie and of Keith. Fortunately these cases are very rare, for operative repair of the grosser defects has so far proved impossible. In a typical example the œsophagus ends in the upper dorsal region as a blind sac joined by a fibrous cord to the lower segment of the

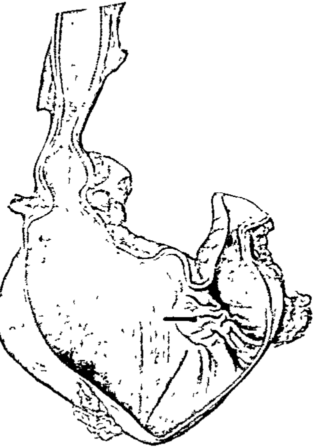

Fig. 2751.—Congenital stricture of the œsophagus. (*Durham University College of Medicine Museum.*)

œsophagus. In 70 per cent of these cases there is a tracheo-œsophageal fistula opening into the lower segment of the tube.

Under such conditions swallowing is clearly impossible and, although gastrostomy may enable the infant to survive for a few days, aspiration of œsophageal contents into the lungs soon leads to fatal respiratory complications. The proposal to combine a gastrostomy with an upper œsophagostomy has proved impracticable, and attempts to carry out plastic repair of the defect by the transpleural route, though of considerable theoretical interest, have been fruitless. Gage and Ochsner

have combined gastrostomy with occlusion of the terminal portion of the œsophagus, and recommend that the upper blind sac should be drained by establishing a cervical œsophagostomy.

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swallowing and regurgitated the fluid as soon as it had been taken. On one occasion only there was a small quantity of blood, but each time she coughed and choked a great deal and became very cyanosed.

I saw the child with Dr. Henry Robinson about noon on January 20, when she was just forty-two hours old. Outwardly she appeared quite normal; but on feeding with a teaspoonful of water she coughed, became cyanosed, retched, and retained none of it The child obviously had a congenital abnormality of the œsophagus, and this was most likely to be in the nature of an œsophago-tracheal fistula. The infant was twenty-five miles from London, and X-ray examination was not immediately available; but, having an œsophagoscopic outfit, I decided to perform œsophagoscopy forthwith. This was done without, of course, any anæsthetic, using a 4-mm tube (Jackson's pattern), which passed quite freely down to and beyond the level of the bifurcation of the trachea. About 1 inch below this level, however, the lumen became obstructed by a glistening membrane with a "mother-of-pearl" appearance, which was at first thought to be inspissated mucus. Careful swabbing, however, showed it to be a solid structure, and no opening could be found in it.

By pressing firmly with the endoscope the membrane was ruptured and normal œsophageal mucosa was seen below it. Gastric mucosa was easily recognised after the tube had been pushed about 1 inch further. On withdrawing the œsophagoscope a few drops of blood obscured the view of the wall of the gullet at the level where the membranous diaphragm had previously been seen. No other abnormality was detected in the pharynx, larynx or œsophagus.

(3) *Mega-œsophagus.*

As Mintz pointed out some years ago, mega-œsophagus is a rare congenital disorder resembling Hirschsprung's disease of the colon—a clinical entity entirely distinct from the symptom-complex of cardiospasm, with which it is still frequently confused. The other condition which has commonly been confounded both with mega-œsophagus and with cardiospasm is the rare para-œsophageal hernia—the "hiatus" hernia of Alkerlund and Van Bergmann, which is described in Section 2 of this article.

In mega-œsophagus there is an enormous dilatation of the entire tube, and the œsophagus pursues a *sinuous course through the chest* (fig. 2752), on radiological examination resembling a large serpent coiled within the cavity of the chest. There is at first no obstruction at the cardia, and the condition appears in many cases to be quite compatible with general health. In a proportion of cases some stasis of ingested material may occur and, possibly as a result of some local inflammatory process, adhesions form between the œsophagus and the surrounding parts. Under these conditions symptoms of dysphagia may appear, due sometimes to a spasm of the cardiac sphincter determined by the fact of local irritation and sometimes to a mechanical distortion of the already disturbed tube.

Treatment, which is only indicated when symptoms of dysphagia are present, must be surgical. A laparotomy is performed, the abdominal œsophagus identified, and its peritoneal covering carefully incised. By blunt dissection the œsophagus is followed a short distance into the mediastinum, and the adhesions between the base of the œsophagus

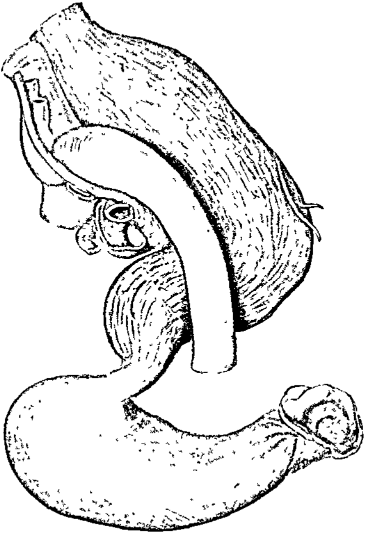

Fig. 2752.—Mega œsophagus.
(*From Morison and Saint's "An Introduction to Surgery" Wright, Bristol*)

and the surrounding parts are separated with the finger. Both Sauerbruch and Tuffier have cured cases in this way. The more complicated operation of plication of the redundant parts of the tube requires exposure of the œsophagus by the mediastinal route, and it should only be considered if the simpler intervention has failed.

(4) *Short Œsophagus.*

Tonndorf in 1923 described a dissection of an old man of 76 in whom the thoracic œsophagus was extremely short and the entire stomach was contained within the mediastinum. The condition has

been recognised during life with increasing frequency since this date, and examples are recorded by Findlay and Kelly, who found in 7 out of 9 cases that the œsophagus ended at the level of the 7th dorsal vertebra. The clinical features of the condition have also been described by Clerf and Manges. It appears that there is often only a portion of the stomach in the mediastinum, and that the œsophageal hiatus in the diaphragm encircles the body of the viscus at a level which varies from case to case.

The condition is not associated with any symptoms, and *treatment* is indicated only if, as sometimes occurs, a stricture develops at the œsophago-gastric junction. Here dilatation may be employed, but attempts at plastic repair of the defect are clearly impracticable as well as being redundant.

FOREIGN BODIES

The impaction of a foreign body is the most frequent cause of acute œsophageal obstruction. Children swallow the most diverse objects—pins, tacks and coins are perhaps the most favoured; in adults a broken piece of denture, a crust or a lump of meat is the commonest cause of obstruction. Apart from mechanical interference, the danger lies in the secondary changes in the wall due to pressure and inflammation, followed by perforation and a spreading mediastinitis usually of a fatal character.

Sauerbruch has observed a case in which a small child coughed up pus and a small metal shoe which had ulcerated through the wall of the left bronchus from the œsophagus. In this case the process had been gradual enough to permit of the formation of mediastinal adhesions, and the child recovered, but such a favourable course is quite exceptional.

In some instances immediate perforation of a mediastinal structure, such as the left bronchus, aorta, heart or pulmonary artery, has been recorded.

Diagnosis is assisted by the history and frequently by the subjective evidence of the patient, who is able to recognise the site of his obstruction; this is usually in one of the narrowest portions of the tube—thoracic inlet, level of the left bronchus, or the cardia. There is often violent retching, which may result in natural elimination. Radioscopic examination will clinch the diagnosis if an opaque foreign body is present; otherwise endoscopy is indicated.

Treatment is urgent and consists in removal of the offending object. The technique of the endoscopic removal of foreign bodies is described on page 4822.

Despite recent advances in endoscopy, there are instances when, in the absence of special apparatus and in rare cases where endoscopy has failed, surgical means must be employed. The extraction of a sharp object, especially if ulceration has already begun, must be conducted with great care, as perforation is likely to have fatal consequences. The classical intervention is *cervical œsophagotomy.*

The operation of cervical œsophagotomy must be carried out with the head low to assist in the protection of the mediastinum, infection of which is the great danger of the intervention. Under local anæsthesia an incision is made along the anterior border of the left sterno-mastoid muscle. The muscle, together with the great vessels, is retracted outwards, and the trachea and the inferior pole of the thyroid gland inwards. Injury of the inferior thyroid artery as it lies behind the carotid sheath, or of the recurrent laryngeal nerve running up between the trachea and œsophagus, must be avoided. The œsophagus lies immediately behind the trachea, and the passage of a bougie may be a guide for the inexperienced operator.

The organ is carefully surrounded by gauze packs, and an incision some 4 cms. long made in its wall. Fixation stitches hold the edges of the œsophageal wound apart, and by means of a headlight and suitable forceps gentle extraction of foreign bodies as far down as the level of the 6th dorsal vertebra may be carried out. A triple layer of sutures closes the œsophageal wound. In the hope of limiting mediastinitis, a pack of antiseptic gauze is left *in situ* and the wound in the neck only partially closed. For the first few days feeding should be by means of a stomach tube passed by the nasal route, or rectal fluids may be given.

Foreign bodies impacted in the lower portion of the œsophagus may be extracted through a gastrotomy wound. In children, a combination of this operation with cervical œsophagotomy makes the whole lumen accessible (Anshutz). In adults, impaction immediately below the level of the 6th dorsal vertebra demands posterior mediastinotomy. Enderlen has had one successful case in which the œsophagus was incised at this site, but the risk of mediastinal infection is so great that it would seem advisable to attempt displacement of the object upwards and so enable its removal from above. The recent work of Seiffert on the successful endoscopic treatment of cases in which perforation and mediastinal infection had already occurred lends further emphasis to the fact that surgical treatment is only to be employed when endoscopy has failed or is unavailing.

The treatment of acute phlegmonous mediastinitis following perforation of the œsophagus by a foreign body is surgical. There are records of recovery after the operation of collar mediastinotomy and drainage, but attempts to institute direct drainage of the posterior mediastinum have so far proved fatal. At the same time this seems the only possible intervention which might save the victim of phlegmonous

infiltration of the lower reaches of the mediastinum, and no doubt some lives will eventually be preserved in this way. Infection of the lung and pleura, which may complicate perforation of the œsophagus by a foreign body, demands surgical treatment along the usual lines.

RUPTURE OF THE ŒSOPHAGUS

Rupture of the œsophagus has been observed after crushing injuries of the chest, but for the most part in association with other grave visceral damage which excluded the possibility of surgical treatment.

Spontaneous rupture of the œsophagus has distinctive clinical features which should suffice to permit of diagnosis and active treatment. The accident always occurs during an attack of vomiting—

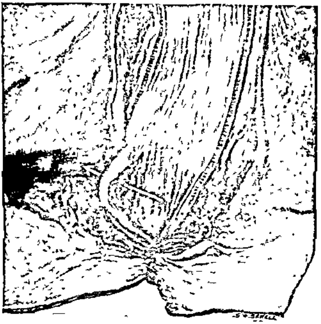

Fig. 2753—RUPTURE OF THE ŒSOPHAGUS.
(*Museum, Middlesex Hospital*)

sometimes an effort has been made to resist the act—and most of the patients have also been victims of chronic alcoholism (fig. 2753). There is a sudden onset of pain, referred to the epigastrium and lower chest, together with a general collapse; the symptoms suggest the syndrome of perforation of a gastric ulcer. There is often an associated rigidity of the upper abdominal wall, and some patients have been subjected to laparotomy. Diagnosis only becomes obvious when escape of air from the œsophagus causes a pneumothorax or a spreading mediastinal emphysema which may eventually be recognised in the neck. Attempts at swallowing are attended with severe pain and may provoke violent attacks of cough.

The rupture consists of a longitudinal tear, some 2 or 3 cms. in length, in the lower reaches of the œsophagus immediately above the diaphragm. The rupture may be extra-pleural, in which case the contents escape only into the mediastinum; in other cases the mediastinal pleura is torn and the contents escape into the pleural space—usually the left.

The *diagnosis* is greatly assisted by early radiological examination at which a pneumothorax or a mediastinal emphysema may be recognised.

The *treatment* should be surgical. After initial treatment for shock the œsophagus should be exposed by the left transpleural route, the defect repaired, and some form of siphon drainage instituted. A gastrostomy should also be performed. The later cases, in which pleural or mediastinal infection has supervened, must be treated by drainage and gastrostomy.

WALKER'S CASE

16.iii.1914. S.G., aged 39, was seized by acute pain in the epigastrium and left lower chest during an attack of vomiting. The patient was not addicted to alcohol but he had eaten a large meal and drunk some whisky shortly before he vomited.

The patient was seen four hours later. Pulse 120. Temperature 97 6. Respiration normal. Rigidity of upper abdomen.

Laparotomy was carried out with normal findings. After this operation the patient became worse and the respiration rate increased. On the following day clear fluid was aspirated from the left chest, and a rib was resected and a drainage-tube inserted.

18.iii.1914. The nurse reported that all nourishment given by mouth was immediately discharged through the chest wound.

19.iii.1914. Gastrostomy performed.

23.iii.1914. Death, and at autopsy there was found a left empyema thoracis and a rupture some two inches long extending upwards from the cardia. The wall of the œsophagus appeared in every way normal.

DIVERTICULA OF THE ŒSOPHAGUS

The clinical features and the operative treatment of the large diverticula or pouches which arise at the junction between pharynx and œsophagus are described in the section on the Surgery of the Neck (see Vol. II, page 1905).

Diverticula of the thoracic œsophagus are divided into two types—pulsion diverticula and traction diverticula.

Pulsion Diverticula.

Pulsion diverticula of the thoracic œsophagus are found only in the region immediately above the diaphragm; to them the term *epiphrenal*

has been applied (fig. 2754). Only in a proportion of cases is the presence of such a diverticulum associated with symptoms, and the syndrome is so rare that Fick could only find a complete account of twenty cases.

The ætiology is not entirely clear, as in some of the specimens the presence of a complete muscular coat would seem to indicate a congenital origin, while in others this layer is wanting and the diverticulum resembles a hernial protrusion of the mucosa and might more properly be termed a sacculus. In any event, it is undisputed that increase in size may result from accumulation of food contents and pressure acting on this mass from the œsophageal lumen. As in the case of other diverticula, inflammatory changes may supervene, a sudden perforation

Fig. 2754.—EPIPHRENAL DIVERTICULUM. (*Lewisham Hospital.*)

of the wall leading to acute mediastinitis, or a more gradual permeation leading to diffuse mediastinal adhesions. In one case adhesions had formed between the diverticulum and the fundus of the stomach, and perforation had brought about natural cure by providing adequate drainage into that viscus. These diverticula are usually small in size, but one as large as the human fist has been reported.

Diagnosis is assisted by the complaint of dysphagia, vomiting of some material, such as rice, known to have been ingested some days previously, and often by the subjective feeling of pressure deep under the sternum. The condition may remain latent for years, and it is only the onset of some complication such as cardiospasm or diverticulitis which brings the patient to seek surgical aid. Radiology is essential to determine the exact site and dimensions of the sac.

Treatment may be palliative or radical. Palliative measures consist in a bland diet, and, in addition, lavage of the sac may be attempted

through the œsophagoscope. Radical measures are justified only if simpler means fail and dysphagia assumes so great an importance as to threaten life. Two operations are possible—extirpation of the sac, or the formation of an anastomosis between the diverticulum and the stomach. Both procedures carry a high mortality, but the latter is the safer of the two. Extirpation of the sac is especially indicated when the diverticulum lies in such a position as to make anastomosis difficult to perform. The successful removal of such a diverticulum by Sauerbruch is recorded by Fick. The transpleural approach was used and, after removal of the sac and section of the phrenic nerve, a pedicle flap of the diaphragm was fashioned and sutured over the œsophageal wound.

The anastomosis operation has been carried out from below the diaphragm by Lotheissen, Kelling and others, and if the sac can be readily exposed by this route it is to be preferred to the transpleural At times the position of the diverticulum demands attack from above, and the first successful case of this type was done by Henschen. In a second case, where massive adhesions made exact anatomical display almost impossible, an incision was made into the diverticulum from within the lumen of the stomach, and this patient was healed. The technique follows the same lines as that of œsophago-gastrostomy and is better divided into two stages: In the first stage the lower œsophagus is exposed by the left transpleural route ; the phrenic nerve is divided, the diaphragm split, and a portion of the fundus drawn up into the chest and sutured to the diverticulum. The wound is closed without drainage. Four weeks later a second thoracotomy is performed and the anastomosis completed.

Traction Diverticula.

Traction diverticula of the œsophagus are seldom diagnosed during life, but at times they assume considerable importance and may even be the cause of fatal illness. Small in size and rarely multiple, these diverticula are the result of chronic inflammatory change in the œsophageal wall. Probably the most common cause of this inflammation is tuberculous disease of the lymph glands at the bifurcation of the trachea, but vertebral caries or pericarditis may be responsible. In some cases portions of ingested food may become lodged in the lumen and so act as a tension factor which contributes to increase in size.

The dimension of these diverticula varies from that of a hazel-nut to that of a walnut. They are usually placed on the anterior wall of the œsophagus, and the apex of the diverticulum is directed upwards.

Diagnosis can only be made after perforation, and this complication

is rarely seen. The accidental inclusion of a sharp fragment of bone in the sac may predispose to it. Perforation into the mediastinum will produce a rapidly-spreading fatal infection unless the ground has been prepared by a previous inflammation, when a localised abscess offers some hope of treatment. Perforation into the bronchial tree—the more usual event—may cause immediate suffocation as the contents are aspirated; or an acute infection of the lung may result, followed in favourable cases by the formation of a localised abscess. The expectoration of ingested material is certain evidence of this catastrophe.

Treatment is indicated only when complications are present. Mediastinal perforation and infection should be dealt with by open operation and drainage. The treatment of those cases of bronchial perforation which survive to present a picture of chronic abscess of the lung is illustrated by a case history below. A suitable drainage operation deals with the pulmonary infection, a plastic operation serves to close the fistula, and finally a second plastic operation is required to heal the defect in the lung.

SAUERBRUCH'S CASE

In December 1915 a soldier of 27 years was treated for a chest complaint which resembled broncho pneumonia. He continued to suffer at intervals from attacks of coughing, hæmoptysis and fever until February 1920, when he was admitted to a sanatorium as a case of phthisis. At this time he frequently expectorated food material and complained that his sputum had a sour taste. In February 1921 he was admitted to the Clinic, and the diagnosis of œsophago-bronchial fistula was confirmed by skiagram.

The following operations were then carried out at suitable intervals:

Operation 1.—Gastrostomy.

Operation 2.—Resection of ribs 5–10, and drainage of abscess in right lower lobe (marked general improvement followed this intervention).

Operation 3.—Return of fever necessitated further opening of the lung abscess, and after this exposure drops of milk taken by mouth could be seen appearing at the upper and inner angle of the cavity.

Operation 4.—The patient insisting on an attempt at radical cure, the fistula was exposed from the mediastinal aspect by resecting the vertebral ends of the previously resected ribs. A sound passed into the fistula from the lung aspect assisted its dissection, but its ligature and repair, as illustrated in figure 2748, were carried out with the utmost difficulty. At the upper angle of the wound, the azygos vein and its entrance into the vena cava were in full view. Three weeks later the patient was able to swallow all food with ease, and the gastrostomy tube was removed.

The persistence of a series of bronchial fistulæ at the site of the original lung abscess—the so-called "lattice lung"—required a plastic operation before final healing was attained.

SIMPLE STRICTURE

Any inflammatory lesion of the œsophagus severe enough to involve destruction of the mucosa and invasion of the muscular wall may be followed by stricture formation. Swallowing of acids or alkalis is the cause of the most extensive strictures, especially if the initial treatment has been neglected.

In Central European countries, lye (a strong caustic solution) is in general domestic use, and this fact may account for the comparative frequency of a condition which is uncommon in this country. The healing of a peptic ulceration of the œsophagus is another rare cause of simple stricture, and the features of a congenital stricture have already been discussed.

There are three levels in the œsophagus at which an anatomical narrowing of the tube may cause the temporary arrest of any corrosive fluid, and there are therefore three sites of election for subsequent stricture formation. These sites are, in order of comparative frequency, the cardiac end, the point at which the left bronchus crosses the œsophagus, and the upper end of the cervical œsophagus. Cases have been observed in which the entire tube has been obliterated by scar tissue, but these are rare; the presence of two separate strictures is more frequent. It may be mentioned that in stricture of the lower end of the œsophagus the abdominal portion usually escapes, and a stricture which may be impermeable from above may be dilated by retrograde dilatation carried out through a gastrostomy opening.

The local decomposition of ingested food above a stricture may initiate a chronic œsophagitis or even local ulceration, and a further extension of such a process into the mediastinum is not uncommon. Once peri-œsophagitis is present, distortion of the normal course of the tube is apt to result. It is under such conditions that a false passage may be caused by an œsophageal bougie. Perforation of the œsophagus in this way is in most cases a fatal accident, but at least one case is recorded in which mediastinotomy and drainage proved successful.

Diagnosis is seldom involved. The late cases are emaciated and show the general features of inanition; all complain of increasing dysphagia. The extrinsic causes of obstruction, especially aneurysm of the aortic arch, mediastinal tumour, and diaphragmatic hernia, must be excluded. The radiographic appearances are usually characteristic, and still more so the endoscopic, while it is only rarely that biopsy is needed in order to exclude carcinoma. There are cases of functional disturbance of the œsophagus in which spasmodic strictures appear at various sites

but, as there is no associated pathological condition of the wall, endoscopy may determine a diagnosis usually quite obvious on general grounds. Cardio-spasm may cause confusion but the mode of onset and the radiographic appearances should be conclusive (fig. 2755).

Treatment must be conservative, and only if repeated attempts at dilatation fail should a plastic operation be considered. Often complete cure may not result as, although the lumen is restored, peri-œsophageal adhesions interfere with the normal function of swallowing; but if the

FIG. 2755.—RADIOGRAPHIC APPEARANCE OF SIMPLE STRICTURE OF THE ŒSOPHAGUS. (*Lambeth Hospital.*)

lumen can be restored such patients are in a more enviable state than that enjoyed by most subjects of an œsophagoplasty.

The technique of dilatation of œsophageal strictures is described on page 5826.

If surgical measures become necessary, the operation of choice would obviously be excision of the affected area and repair by end-to-end anastomosis. At present the technical difficulties of such a manœuvre are too great, and recourse to some form of œsophagoplasty is compelled. It is rarely that conditions permit of an œsophago-gastrostomy, a procedure which is more easily performed for the relief of cardiospasm. There are few surgical problems in which greater ingenuity has been displayed than in the replacement of the œsophagus by substitution of some other viscus. The technique of œsophagoplasty is described later in this section.

ŒSOPHAGITIS

Acute œsophagitis is sometimes observed as a complication of one of the acute specific fevers. The condition merely demands symptomatic treatment, except in rare cases of diphtheritic infection when periodic dilatation during the convalescent period may be indicated as a prophylactic measure against stricture formation.

The swallowing of corrosive fluids such as lye or concentrated acids produces an acute œsophagitis which may demand energetic treatment. The most severe cases, in which there is massive necrosis of the wall of the œsophagus with early perforation, are doomed and operation is useless. The mild cases, in which the constitutional symptoms are slight and fluids can still be assimilated, do not require operation. But the intermediate group, in which the degree of local damage is enough to prohibit the taking of fluids despite a general recovery from the immediate collapse attendant on the accident, do require surgical treatment. A gastrostomy should be performed, and in this way rest of the inflamed area ensured. After twenty-one days, feeding by mouth is resumed, and if the radiological appearances are abnormal the question of periodic dilatation must be considered. Under no circumstances should any instrument be passed in the acute stage.

Acute suppurative œsophagitis has already been mentioned as a complication of an impacted foreign body—usually a sharp spicule of bone. Once suppuration reaches the loose submucous tissues, a spreading phlegmonous inflammation may result. Treatment in localised suppuration is endoscopic removal of the foreign body, but œsophagitis of the phlegmonous type is fatal.

Chronic œsophagitis may be an incident in chronic alcoholism, and it is frequently associated with diverticulum or stricture as a result of an unnatural accumulation of ingested material. Treatment must be symptomatic or directed towards the associated disease.

Ulceration may be a feature of any type of chronic œsophagitis, but of special importance are the tuberculous, syphilitic and peptic ulcers.

Tuberculous ulcers are most common in the middle third of the tube, and are usually an incidental finding at autopsy or in an advanced case of phthisis. One case is recorded in which symptoms of cardiospasm developed and a solitary tuberculous ulcer was detected in the lower reaches of the tube. As tuberculous ulceration is almost invariably a late event in a progressive and fatal disease, active treatment is rarely indicated. At the same time, if dysphagia is marked and

cannot be relieved by internal remedies, local treatment of the ulcer by endoscopic means may be considered.

Syphilitic ulceration of the œsophagus is very rare, but its occasional presence *is sufficient reason for endoscopic as well as for serological* investigation before a diagnosis of carcinoma is finally determined. There are records of such cases which progressed to a fatal termination from inanition and in which the diagnosis was only established at autopsy. Also of practical importance is the record of another case in which a syphilitic ulcer of the œsophagus perforated into the left bronchus and an œsophago-bronchial fistula resulted. Healing followed a course of anti-luetic treatment.

Peptic ulceration of the œsophagus has assumed greater importance of recent years, as improved radiological technique has supplemented endoscopic investigation to enable confident diagnosis of the condition. Peptic ulcer in the œsophagus may assume the same form as in its more usual sites—there may be a large single chronic ulcer or the mucosa over a wide area may be studded with multiple areas in which destruction of the superficial epithelium has occurred (fig. 2756). The usual complications of peptic ulcer may be observed—erosion of a vessel may cause hæmorrhage, perforation of the ulcer is followed by

Fig. 2756.—Multiple peptic ulceration of the œsophagus.
(By courtesy of Professor Hamperl, Berlin.)

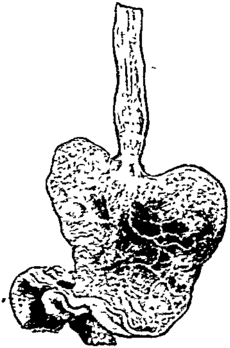

Fig. 2757.—Fibrous stricture of the œsophagus following peptic ulceration.
(By courtesy of Professor Hamperl, Berlin.)

acute pleural or mediastinal infection, and healing of the ulcerated area may leave a fibrous stricture (fig. 2757). The ætiology remains obscure, but the site of the solitary chronic ulcer—almost invariably at the cardiac end of the tube—suggests that regurgitation of the acid gastric contents plays some part in the process. In some cases histological examination has demonstrated the presence of a heterotopic segment of gastric mucosa in the affected area.

Peptic ulceration of the œsophagus is accompanied by pain, dysphagia, vomiting and hæmorrhage. The pain is usually referred to the epigastrium—some patients have described its site as "behind the breast bone," while in others pain has been felt especially in the back at the level of the 5th dorsal vertebra. In contra-distinction to the pain of gastric ulcer, the pain of an œsophageal ulcer is felt immediately after ingestion of food.

The dysphagia is caused by associated spasm of the œsophageal wall and is a variable symptom.

Although the patient will usually complain of vomiting, close investigation will show that it is an evacuation of œsophageal rather than of gastric contents which takes place.

Hæmorrhage may become apparent in various ways. Small quantities of bright red blood may be brought up, or blood may flow down into the stomach and then be either vomited or passed on into the intestinal tract.

As a result of these disturbances the general health becomes much reduced, and some of the early cases came to autopsy under the diagnosis of pernicious anæmia. It must also be stated that coincident ulceration of the stomach or duodenum has often been observed.

The diagnosis can only be established by radiological and endoscopic examination. Endoscopy is to be employed only if radiology fails to demonstrate the ulcer.

The *treatment* of peptic ulcer of the œsophagus should be in the first place conservative. If rest and internal remedies fail to give relief, jejunostomy or gastrostomy is indicated. In some cases actual excision may be required. The treatment of a stricture following an old peptic ulceration differs in no way from that of any other simple stricture of the œsophagus. Operative treatment of perforation of a peptic ulcer has proved disappointing. There have been one or two successful interventions for perforation of an ulcer of the lower œsophagus into the peritoneal cavity, but on only one occasion has mediastinotomy for a higher perforation saved the patient.

Roessler has recently reviewed this subject in great detail, and he

describes the treatment of five cases recently diagnosed and treated in the Sauerbruch Clinic. One of the operations—excision of the lower end of the œsophagus with immediate restoration of continuity—is of great technical interest, and the following case history illustrates the general features of the syndrome:

CASE OF PEPTIC ULCER OF THE ŒSOPHAGUS

The illness began with pain behind the xiphisternum some seven years before admission to hospital. There were frequent attacks of vomiting, in which undigested food was brought up. From time to time there were remissions, but on the whole the condition gradually became worse, and on admission the patient was quite unable to assimilate food. The skiagram showed the outline of an ulcer immediately above the cardia.

Laparotomy was performed and the presence of a lesion in the lower œsophagus confirmed by palpation. A jejunostomy was carried out and for some weeks no food was given by mouth. It was then found that swallowing caused no pain or distress, the jejunostomy was allowed to close, and the patient resumed a normal diet.

The patient was examined some three years later, when he was in good health and radiological examination of the œsophagus showed it to be normal.

NEOPLASMS OF THE ŒSOPHAGUS

Innocent.

The following types of innocent tumours have been described: cysts, papillomata, myomata, fibromata and lipomata. These tumours are rare and only occasionally give rise to symptoms, but that they occur is important because instances have been recorded in which the diagnosis has only been established at an autopsy carried out on the victim of a supposedly malignant growth.

The *cysts* take origin in the submucous tissues and project into the lumen of the œsophagus, usually on the anterior wall. They rarely attain more than the size of a hazel-nut. For the most part such cysts pursue a symptomless course. They have occasionally been observed during a routine œsophagoscopy. More rarely cysts, presumably of congenital origin and lined by ciliated epithelium, have been described; the clinical features of such a case are illustrated in the following history:

SAUERBRUCH'S CASE

In 1930 a small boy aged 13 years was seized with curious attacks characterised by collapse, dysphagia, and extreme cardiac irregularity. Medical treatment failed to give relief, the symptoms of cardiospasm soon appeared, and on admission to the Clinic only fluids could be swallowed and those with difficulty. Radiological examination disclosed a rounded shadow in close relation to the œsophagus, immediately above the diaphragm.

Operation 15.vi.31. The lower œsophagus was exposed by the left transpleural route. On its anterior wall, about 5 cms. above the cardia, was a cystic

tumour the size of a pear. It was at first assumed that the structure must be an epiphrenal diverticulum, but when it was opened there was no communication with the œsophageal lumen. After careful dissection the cyst was removed from its site in the muscular coat of the œsophagus. The wound was closed in layers without drainage.

The report on the tumour (Prof. Roessler) stated that it was an epithelial cyst which had formed in early embryonic life.

Convalescence was complicated by an infective pleural effusion which required siphon drainage, but in eight weeks the patient was discharged symptom free, having gained 10 lb. in weight.

The *papillomata* are only to be recognised by endoscopy, and are readily susceptible to treatment by the cautery.

Fibromata and *lipomata* take origin in the submucous tissues and project into the lumen of the tube. In course of time these tumours acquire a pedicle and assume a polypoid form. There is one case recorded in which such a tumour, taking origin in the upper œsophagus, could be extruded from the mouth. In all cases endoscopy is necessary to establish the diagnosis, and treatment may be carried out by the same route.

The number of *myomata* recorded in the literature is very small (fig. 2758). At times these tumours project into the lumen, but as frequently they develop outwards and may come to exert pressure on other structures in the mediastinum. The following case history (Sauerbruch) illustrates the features of an operation case in which the tumour caused in its end stages the symptoms of cardiospasm.

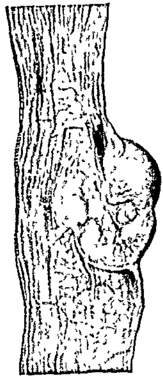

Fig 2758.—Myoma of the œsophagus.
(Museum, St Thomas's Hospital. By courtesy of Professor Dudgeon.)

CASE OF FIBROMYOMA OF THE ŒSOPHAGUS

For the last three years the patient, a policeman aged 33, had suffered from pain behind the sternum and from dysphagia. A laparotomy had been done under a false diagnosis of peptic ulcer, and then the patient got some measure of relief by the passage of œsophageal bougies. Finally, swallowing became literally impossible, and in this condition he was admitted to the Clinic.

Radiological examination displayed a rounded shadow in the lower œsophagus, suggesting the presence of a benign tumour.

Operation 9.iii.33. With the patient lying on his right side, under positive pressure anæsthesia, the left chest was entered after resection of the 9th and 10th ribs. There was found a tumour of irregular outline which surrounded the lower

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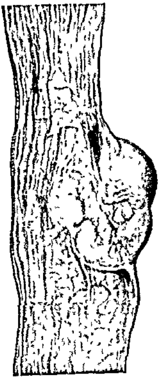

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end of the œsophagus as if it were grasped by a hand. The tumour was excised with some difficulty and in the process a defect was made in the wall of the œsophagus. This defect was closed by suture and, as the formation of a stricture at this site seemed likely, an œsophago-gastrostomy was carried out. The chest wound was closed and a high jejunostomy performed.

The tumour proved to be a fibromyoma.

The patient made a good recovery from this operation. After five weeks, normal swallowing was possible and the jejunal tube was removed. Radiological examination showed a free passage for the contrast medium.

Malignant.

Sarcoma of the œsophagus is a very rare disease. It may be of interest to note that it is more common after the age of 40. Although a certain diagnosis can only be reached by biopsy, the condition may be suspected if there is marked emaciation at a stage when œsophageal obstruction is not a prominent symptom and the patient is still able to assimilate his food.

There is no record of radical surgical intervention for sarcoma of the œsophagus, and in most cases death results from widespread metastases before the threat of inanition requires gastrostomy.

Carcinoma of the Œsophagus.

Carcinoma of the œsophagus is a disease of middle life, although it has been observed in a man of 21 years. It affects men more frequently than women (Souttar records that of 15,000 patients suffering from carcinoma of the thoracic œsophagus only 3850 were women), and its sites of election are the thoracic inlet, the level of the left bronchus, and the lower third of the œsophagus.

The records of the Breslau Pathological Institution (1878–1900) show the following results: 17,947 autopsies were done; 1674 showed carcinoma, of which 204 were carcinoma of the œsophagus:

Cervical œsophagus	26
Thoracic inlet to bifurcation of trachea	14
Level of hilus of lung	29
Between hilus and cardia	117
Whole œsophagus involved	3
Site not recorded	15

From these figures it would appear that the lower third is the most frequent site of growth, and Schmidt, who analysed 772 cases, came to a similar conclusion.

Sauerbruch found that 35 per cent of the 117 cases in which the growth was situated between the hilus and the cardia died without forming distant metastases, although in most of them life had been prolonged by means of a gastrostomy.

Clayton, in a careful post-mortem study of 41 cases, found that 10 had died without forming glandular or distant metastases. Starlinger found that 66 per cent of the cases he examined were without metastases, and Hesley arrived at a similar result. Some might regard these conclusions as unnecessarily favourable, but, judged on its natural history alone, cancer of the œsophagus should be at least as amenable to treatment as cancer of other portions of the alimentary tract. Its fatality lies in the fact that local extension must involve vital structures with comparative rapidity, in the possibility that symptoms may only

Fig 2759.—Scirrhous carcinoma of the œsophagus. The œsophagus has been bisected longitudinally and each half held open to display the inner surface

(*Durham University College of Medicine Museum.*)

appear late in the course of the disease, and in the purely technical difficulty of excising the growth.

The majority of growths show the histological structure of squamous-celled carcinoma (fig. 2759). Adeno-carcinoma may be seen in the lower third, with its origin in the cells of the gastric mucosa, and it tends to run a very malignant course (see fig. 2760). Basal-celled carcinoma with its usual general characteristics has been reported. Scirrhous types of growth are frequent, or the tumour may take the form of a fungating polypoid mass or of an ulcer. Peptic ulcer of the chronic solitary type may so closely simulate carcinoma that only a biopsy can establish diagnosis.

The expectation of life after diagnosis of a carcinoma is short—9 to

14 months even if gastrostomy is carried out. Turner records the case of a man of 52 who survived for almost 2 years, and at autopsy no local or general dissemination was found. Direct extension of the growth, with perforation into the left bronchus, aorta,

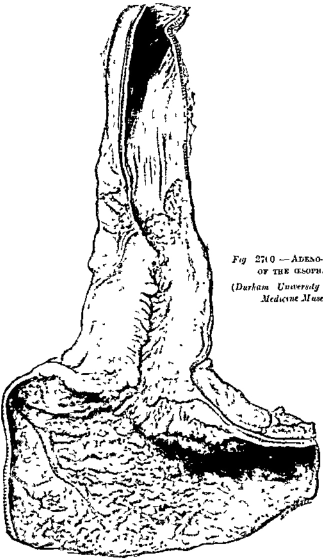

Fig. 2710.—Adeno-carcinoma of the œsophagus. (Durham University College of Medicine Museum.)

pericardium, pleura or mediastinum, has been recorded. Some patients escape such complications and perish from inanition, but suppuration in the lung, pleura or mediastinum commonly determines death.

The *diagnosis* of carcinoma of the œsophagus is seldom difficult once definite symptoms of obstruction are present. Dysphagia may be a fluctuating symptom in the case of growths which undergo marked

necrosis, as a result of which the obstruction becomes temporarily relieved. The patient will frequently begin the day by emptying his œsophagus of the white tenacious mucus which has accumulated above his growth during the night.

The history is usually one of increasing difficulty in swallowing, at first overcome by increased muscular effort. Pain is not at first a prominent symptom, although vague substernal discomfort may be experienced as the growth extends or as the lymphatic glands are involved. Later, pain may become a feature of the disease. Invasion of the left recurrent laryngeal nerve or of the sympathetic trunk, with corresponding change in larynx and pupil, may be associated with growths of the upper part of the viscus.

Endoscopy offers the only hope of early diagnosis and is essential in all cases to assess the type and form of the tumour. Biopsy should be an essential preliminary to active treatment. On endoscopy an early growth may demonstrate its presence by limiting or abolishing the normal enlargement of the lumen at each inspiratory act. The growth

Fig. 2761.—Skiagram showing diffuse carcinoma of the œsophagus
(*Lambeth Hospital.*)

Fig. 2762.—Skiagram showing carcinoma of the œsophagus with marked dilatation of the tube above the growth.
(*Lambeth Hospital.*)

itself may be visible, and its site is often indicated by the proximity of blood-stained mucous secretion.

Radiology enables a clear distinction to be made between those growths which act as a stricture and those in which little stenosis is present but where the wall of the œsophagus is widely involved. Examination by the fluorescent screen after ingestion of some opaque medium may help to localise the site of the growth (see figs. 2761 and 2762).

The *treatment* of carcinoma of the œsophagus may be palliative or active. A palliative measure often neglected is alleviation of the symptoms by morphia and the local application of cocaine. The other measures possible are gastrostomy, intubation, or dilatation by sounds. The relative merits of early or late gastrostomy are still the subject of dispute, and the personal preference of the patient should be considered in reaching a decision. It must be realised that the immediate mortality of the operation is high when the general condition has deteriorated, and that, while an early gastrostomy will enable a fair degree of nutrition to be maintained, it is very difficult to improve the condition of an emaciated patient by the operation. An early gastrostomy should obviously be preferred if radical treatment, either by surgical or by endoscopic means, is contemplated. Not all cases are suitable for intubation, and it demands skilled technique, but it has the advantage of enabling the patient to regain his power of swallowing and to lead, if only for a time, his normal existence. The passage of bougies to maintain an open passage is fraught with grave danger from immediate perforation, but in the absence of special apparatus for intubation it will enable a gastrostomy to be postponed, and if the patient is warned of its immediate dangers there are circumstances in which it would seem to be a justifiable mode of treatment.

The growing importance of physical therapy in the treatment of malignant disease is especially emphasised in the treatment of carcinoma of the œsophagus. It has gained this importance because of the high mortality of surgical interventions rather than by virtue of its own efficacy. As Clayton points out, it seems unlikely that the simple application of radium will become an effective agent, for in most cases the wall is deeply involved and, even if it were possible to destroy the cancer cells, the patient is likely to die from the effects of perforation. Guisez has recently demonstrated five successful cases treated by radium by the endoscopic method, but he seems alone in this fortunate experience. Hotz, Anshutz, Chaoul and others have worked along similar lines and have also employed deep X-ray therapy, with amelioration of symptoms in some cases but without curing the disease. Attempts

have been made to treat carcinoma of the œsophagus by applying radium or radon seeds to the exterior of the growth after surgical exposure, but the results have so far not been encouraging. Clairmont reported the cure of a case, in which biopsy had confirmed the diagnosis, by means of deep X-ray therapy—the method of Coutard being employed. His patient died of pneumonia nine months after termination of the treatment, and at autopsy no sign of the growth could be found.

The ideal surgical treatment of carcinoma of the œsophagus is excision and restoration of the canal, but, although this ideal has been attained in a few isolated cases, it has so far proved impossible to elaborate a standardised technique which would enable œsophagectomy to be carried out with the same general success as gastrectomy. Not only does the anatomical site of the œsophagus render this difficult, but most patients are seen when the disease is advanced and their general condition makes them poor subjects for a surgical intervention of complexity and magnitude.

Although the ideal is not yet attained, the work of von Mikulicz, Sauerbruch, Enderlen, Zaaiger, Torek, Lilienthal and others has helped to advance the general position of surgery in the chest. von Mikulicz first conceived the principle of the transpleural approach. Sauerbruch, by his early studies on dogs, was able in 1904 to show thirteen surviving animals after transpleural œsophagectomy and œsophago-gastrostomy. In these animals the diaphragm was incised and the stomach partially displaced into the thoracic cavity, a measure which had been foreshadowed by Block many years previously and which has proved of the greatest value in restoring continuity of the tube despite its inextensible nature. Later, the method of invagination for tumours at the cardiac end was elaborated and in one case this was technically successful.

Enderlen was the special protagonist of the posterior mediastinal route—an extra-pleural operation has obvious advantages, but the less adequate exposure adds operative difficulties.

Torek excised a carcinoma of the œsophagus and his patient was alive thirteen years later; during the whole of this time nutrition was maintained by means of a rubber tube which joined the cervical œsophagus to a gastrostomy opening. The growth lay at the level of the aortic arch and, after division of the œsophagus and closure of the aboral end, a second incision was made in the neck, by which the oral end of the œsophagus together with the growth was brought out to the surface. Torek had been impressed with the fatality which attended attempts to close the oral end of the divided œsophagus *in situ*—the

accumulated secretion invariably penetrated the suture line to infect pleura and mediastinum—and his treatment of the oral end, although it involved a very extensive dissection, avoided this danger. More recently, Eggers successfully operated on a man of thirty-eight by a similar method, and in this case continuity was restored by means of a rubber tube.

Lilienthal, operating by the posterior mediastinal route, was able to excise a growth lying above the cardia. His patient survived with normal powers of swallowing after an œsophagoplasty in which the skin of the back was used after the method of von Häcker.

Although Zaaiger, as well as Torek, has had a surviving patient after excision of the œsophagus and dislocation of the oral end up into the neck, the operation is one of great severity. The fascial planes of the mediastinum are opened up and this renders post-operative sepsis especially dangerous, while there is also immediate danger from hæmorrhage as the œsophagus is dissected from its bed.

The mode of approaching the growth must be judged on its merits. There are advantages in an extra-pleural approach, but it adds to the operation time and there are few patients who can withstand an intervention which lasts for more than three hours—the time required in Eggers' case. There are some cases which may be accessible from below the diaphragm. Gohrbrandt was able to excise 5 cms. of the lower end of the œsophagus by the abdominal route and to restore continuity by implanting the oral end of the tube into the stomach.

The ideal method of replacing the excised portion of œsophagus is not yet developed. The utilisation of a loop of bowel, while it has met with success in cases of simple stricture, is so severe a procedure for the carcinoma patient that only Turner's case has been known to survive. The experimental work of Neuhof and Ziegler, who restored continuity of the cervical œsophagus in dogs by allowing natural granulations to form round a rubber tube, has not so far found clinical application. Thoracic dislocation of the stomach, as elaborated by Kirschner, offers most hope as it enables restoration of continuity by direct anastomosis between the oral end of the tube and the stomach.

Descriptions of the endoscopic treatment of carcinoma of the œsophagus appear in the appropriate sections, where are described, in addition to the palliative measures such as intubation, the local application of radium, local removal of a tumour, and treatment by diathermy.

It is obvious that some of the methods of treatment outlined can profitably be combined in any given case. Thus, for example, gastro-

stomy may be required in cases where endoscopic diathermy of the tumour is attempted, and frequently the local use of radium is supplemented by deep X-ray therapy.

CARDIOSPASM

There are references in the eighteenth-century literature to a curious disorder in which there is enormous dilatation of the œsophagus, an increasing and perhaps ultimately fatal dysphagia, and yet even the primitive œsophageal sounds in use at that date could be passed without difficulty into the stomach, while after death dissection failed to reveal any organic cause of œsophageal obstruction.

In modern times the diagnosis of cardiospasm was first attached to these cases by von Mikulicz, and he was able to show that the spasm was often accompanied by some local focus of irritation. In one case there was a fissure in the œsophageal wall and in others peptic ulceration of the œsophageal wall was present. More recently, cases have been recorded in which the irritative cause has been an epiphrenal diverticulum or an innocent tumour. It has also been found that the syndrome may be initiated by some sudden emotional shock, and in these patients the syndrome is due to a central and not to a local nervous disturbance.

Hurst would substitute the word " achalasia " for cardiospasm. He believes that there is no actual spasm but that the normal relaxation of the cardia fails to occur; in this view he is supported by Rieder, who carried out section of the muscle coat at operation on twelve cases but failed to demonstrate hypertrophy, and by Cameron, who made a similar observation at an autopsy.

The balance of evidence is against those who would localise the disturbance in the œsophageal hiatus of the diaphragm and label the syndrome phrenospasm. There have certainly been one or two cases in which operation has disclosed some hypertrophy of that strip of muscle-fibres which normally encircles the lower end of the œsophagus, and section of these fibres has brought relief, but this is quite an exceptional finding.

Mega-œsophagus has already been described (see page 5048), and the reasons for considering it as a separate syndrome enumerated. Cardiospasm may be associated with mega-œsophagus, especially if secondary changes of an inflammatory nature are present, as these may provide a focus from which irritative impulses pass to the cardia. The enlargement of the œsophagus in cardiospasm is spindle-shaped, and the organ does not display the sinuous outline of mega-œsophagus.

The normal œsophagus has at the most a capacity of 150 cc.—in these cases the capacity may exceed a litre. There is at first hypertrophy of the œsophageal musculature, but if the condition persists a secondary atrophy appears and the thin wall of the dilated œsophagus is then liable to perforation when instrumentation is attempted.

The clinical features of cardiospasm are never entirely uniform. In cases of central origin the onset may be sudden and in direct relation to some emotional shock. The operation of some local irritative focus like a peptic ulcer or a tumour will usually produce a more gradual onset of symptoms. Once the syndrome is established, the symptoms in general resemble those of stricture of the œsophagus, except that

Fig. 2763.—Skiagram illustrating severe degree of cardiospasm.
(*Lambeth Hospital.*)

periods of remission are more usual. In the early stages of the disorder the patient practises various manœuvres to assist in deglutition, but as it progresses these become ineffective. As time goes on and the size of the œsophagus increases, symptoms due to pressure on the mediastinal structures may become apparent, more especially palpitation and attacks of cardiac arhythmia. In the later stages decomposition of retained food material in the dilated tube adds to the general distress, and at times aspiration of infected detritus may set up an infective process in the lung which may either terminate in an acute gangrene or progress to chronic suppurative pneumonitis.

The *diagnosis* is often clear on clinical grounds, but the presence of some associated lesion, such as a tumour or stricture, can only be revealed by radiological examination (fig. 2763). The patient complains of an

increasing dysphagia, remarkable in that long periods of complete remission may occur. In late cases emaciation and the signs of œsophageal obstruction are present. Patients complain of a foul taste in the mouth; some have developed a trick by which they maintain some degree of comfort by periodically irritating the pharynx and evacuating the œsophageal contents; others find that dry, solid materials can be taken while semi-fluid substances fail to reach the stomach, or the reverse may be experienced.

In many cases the passage of a stomach tube, with the successive evacuation of œsophageal contents and gastric juice, may demonstrate the nature of the disorder.

The radiological examination should include examination before the fluorescent screen while some opaque material is swallowed. The technique of endoscopic examination of cardiospasm is detailed elsewhere. It should be done in all cases to exclude the presence of some local cause for the syndrome.

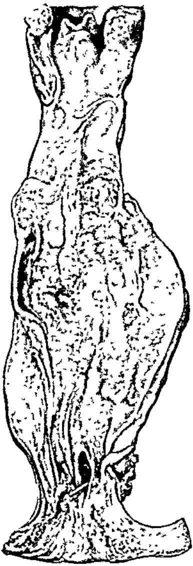

Fig 2764.—Cardiospasm. Death followed perforation by a mercury tube passed by the patient.

(*Durham University College of Medicine Museum.*)

Treatment must be modified according to the circumstances of the case, and *only in the last resort should it be* operative.

Cardiospasm in a nervous subject can often be cured by psycho-therapy. Drug treatment with suitable doses of atropine and pilocarpine is sometimes helpful, despite the antagonistic nature of their action.

Dilatation by the simple bougie is usually ineffective, and recourse must be had to the hydrostatic dilator of *Gottstein-Geissler or to the* mercury tubes of Hurst. The hydrostatic dilator must be used with caution, as fatal rupture of the œsophagus has been recorded. Hurst employs rubber tubes, each filled with the same weight of mercury (1 lb. 5 oz.), which are passed in the usual way and allowed

The normal œsophagus has at the most a capacity of 150 cc.—in these cases the capacity may exceed a litre. There is at first hypertrophy of the œsophageal musculature, but if the condition persists a secondary atrophy appears and the thin wall of the dilated œsophagus is then liable to perforation when instrumentation is attempted.

The clinical features of cardiospasm are never entirely uniform. In cases of central origin the onset may be sudden and in direct relation to some emotional shock. The operation of some local irritative focus like a peptic ulcer or a tumour will usually produce a more gradual onset of symptoms. Once the syndrome is established, the symptoms in general resemble those of stricture of the œsophagus, except that

Fig. 2763.—Skiagram illustrating severe degree of cardiospasm.
(*Lambeth Hospital.*)

periods of remission are more usual. In the early stages of the disorder the patient practises various manœuvres to assist in deglutition, but as it progresses these become ineffective. As time goes on and the size of the œsophagus increases, symptoms due to pressure on the mediastinal structures may become apparent, more especially palpitation and attacks of cardiac arhythmia. In the later stages decomposition of retained food material in the dilated tube adds to the general distress, and at times aspiration of infected detritus may set up an infective process in the lung which may either terminate in an acute gangrene or progress to chronic suppurative pneumonitis.

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The radiological examination should include examination before the fluorescent screen while some opaque material is swallowed. The technique of endoscopic examination of cardiospasm is detailed elsewhere. It should be done in all cases to exclude the presence of some local cause for the syndrome.

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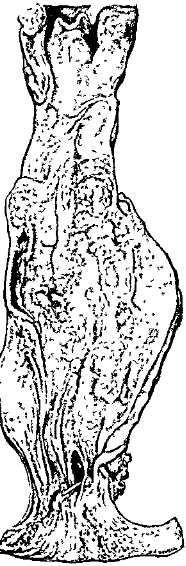

Fig 2764.—CARDIOSPASM. DEATH FOLLOWED PERFORATION BY A MERCURY TUBE PASSED BY THE PATIENT.

(*Durham University College of Medicine Museum.*)

Dilatation by the simple bougie is usually ineffective, and recourse must be had to the hydrostatic dilator of Gottstein-Geissler or to the mercury tubes of Hurst. The hydrostatic dilator must be used with caution, as fatal rupture of the œsophagus has been recorded. Hurst employs rubber tubes, each filled with the same weight of mercury (1 lb. 5 oz.), which are passed in the usual way and allowed

to remain in position for five minutes. The intervals at which they are employed are gradually lengthened, and the patient is taught to use them himself until such time as his symptoms are relieved. Vinson, reporting on 679 cases treated by hydrostatic dilatation (the dilator being guided by a previously-swallowed thread), found complete healing in only 188, and 117 patients retained dysphagia of moderate or considerable degree. Dilatation methods can only be expected to succeed in the absence of some organic lesion which is serving as an irritative focus

Spasm of the cardia secondary to a peptic ulcer of the lower œsophagus might be treated by gastrostomy and suitable diet, while if the ulcer lay high on the cardiac end of the stomach a jejunostomy might attain the same end. A congenital valvular obstruction or polypus in the lower œsophagus might be dealt with by endoscopy.

The oldest direct operation on the cardia is that of digital dilatation of the orifice from within the stomach. von Mikulicz did this six times, with success in five cases, and Walton has recorded a later series of successful cases. This method. like hydrostatic dilatation, is likely to fail if a focus of irritation is present.

The role of denervation in the treatment of cardiospasm is discussed in Vol. II, page 3152. Clairmont performed and carried out section of the lower vagal fibres, while more recently Knight has practised sympathectomy.

Three direct operative procedures have been carried out—Heller's operation of section of the muscle coat, the operation of cardioplasty, and the operation of œsophago-gastrostomy. Heller reported 20 cases treated by his method, with success in 18, and similar results were obtained by Payr, Enderlen, Zaaiger, Sauerbruch and others. More recently good results have been reported by Rieder. Sauerbruch has done this operation 7 times: there was 1 post-operative death from meningitis, 5 cases were cured, and 1—who was actually a case of mega-œsophagus—got merely temporary relief. This is probably the operation of choice if there is intrinsic spasm, but it is likely to fail if the spasm is secondary to some local focus of irritation.

Œsophago-gastrostomy is to be preferred to cardioplasty because it provides more certain relief. Successful transpleural œsophago-gastrostomy has been reported by Sauerbruch, Henschen and Enderlen, while Turner and Fromme have used the abdominal route with success.

SURGICAL EXPOSURE OF THE ŒSOPHAGUS[1]

Exposure of the Thoracic Œsophagus.

The thoracic œsophagus has been exposed in cases of carcinoma, benign tumour, diverticulum, and for the extraction of foreign bodies. Two routes are available for exposure—the mediastinal and the transpleural. von Mikulicz was perhaps the first surgeon to make a determined attempt to exploit the surgery of the thoracic œsophagus, and, after repeated trials of the mediastinal route, he came to the conclusion that only the transpleural route could give adequate exposure. The chief modern advocate of the transpleural route is Sauerbruch. Enderlen, on the other hand, preferred the mediastinal route, and his account of the surgery of the posterior mediastinum is of the utmost value. Lilienthal still employs this approach, and it may be noted that one of the few cases in the world literature up to 1933 in which natural swallowing was restored after excision of a carcinoma was carried out by him. All authorities are agreed that the mediastinal approach is to be preferred in such cases as impaction of a foreign body necessitating œsophagotomy, in intervention for perforation or rupture of the organ, or in extirpation of small diverticula which have perforated into a bronchus. In this type of case it is a considerable advantage to be in a position to leave a large open wound for drainage.

In exposing the upper thoracic œsophagus by the transpleural route, Sauerbruch resects the 2nd and 3rd ribs from the sternal margin for 6 cms. of their extent, incises the sterno-clavicular joint, dislocates the sternal end of the clavicle, and finally resects a portion of the 1st rib. The pleura is opened by a vertical incision and the œsophagus identified as it lies behind the trachea. Barrett has recorded an operation by Romanis in which a diverticulum was removed which opened into the œsophagus just below the level of the azygos vein. Approach in this case was made through an incision in the 6th intercostal space.

For his successful case of radical operation for carcinoma, Torek made an incision along the whole length of the 7th left intercostal space. The 4th, 5th, 6th and 7th ribs were divided in the region of the tubercle and the pleura incised. With this exposure an excision of the entire œsophagus from the diaphragm to the thoracic inlet was carried out under vision. Kirschner has used the same interspace in displaying the lower œsophagus and the region of the cardia. Division of the 7th

[1] The anatomical measurements recorded were made during a joint investigation with Mr. R. W. Raven.

costal cartilage and the left rectus muscle permits of a wide exposure of the diaphragm, and, if necessary, this muscle is divided in a line stretching from the œsophageal hiatus to the periphery. Hedblom and Zaaiger have employed a very similar approach, but these authorities consider that a preliminary resection of the lower ribs carried out some 10 days before the final operation facilitates the subsequent exposure. A left transpleural approach to the lower œsophagus is also used by Sauerbruch, and this route was adopted by Eggers in his successful case.

Gregoire has described in minute detail an extra-pleural approach to the lower end of the thoracic œsophagus. He resects the 12th rib on the left side, and after simple division of the 10th and 11th ribs the pleura is separated from the costo-vertebral sulcus. The œsophagus is

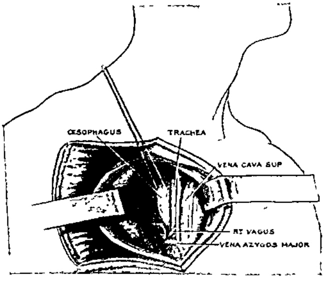

Fig. 2765.—EXPOSURE OF THE THORACIC ŒSOPHAGUS ABOVE THE BIFURCATION OF THE TRACHEA BY THE RIGHT TRANSPLEURAL ROUTE. THE RIGHT LUNG IS RETRACTED OUTWARDS AND THE ŒSOPHAGUS IS SEEN BEHIND THE TRACHEA AND CROSSED BY THE VENA AZYGOS MAJOR AND THE RIGHT VAGUS NERVE.

(*O'Shaughnessy and Raven. By courtesy of the "British Journal of Surgery."*)

exposed between the aorta on the medial side and the lung, covered by the separated costal pleura, on the lateral side. By incising the diaphragm and so exposing the cardiac end of the stomach Gregoire has carried out an œsophago-gastrostomy by this route.

Lilienthal enters the mediastinum after resection of the 9th rib on the left side. According to the exposure required, further ribs are excised after separation of the parietal pleura has been begun. Lilienthal mentions the descending thoracic aorta and the great splanchnic nerve as important landmarks in the initial stages of the operation.

Technique.

(1) *Right Transpleural Exposure of the Upper Œsophagus* (fig. 2765). The patient lies on his back with the upper extremities extended by his side. An incision 10 cms. long is made over the 2nd rib from without inwards to the sternum. It is then carried vertically down-

wards over the sternum to the 4th costochondral junction and from thence outwards *for 10 cms in the line of the 4th rib.* This flap, consisting of the skin, superficial and deep fasciæ, and costo-sternal portion of the pectoralis major and pectoralis minor muscles, is dissected from the deeper structures and reflected outwards. The periosteum is reflected from the 2nd and 3rd ribs over 12 and 14 cms. of their length respectively, and similar lengths of these ribs, together with their costal cartilages, are removed. The internal mammary artery and veins are exposed in the inner part of the wound. An incision is made in the 2nd intercostal space to open the pleural cavity. The right lung is retracted outwards and downwards and the following structures are identified: the superior vena cava with the right phrenic nerve and

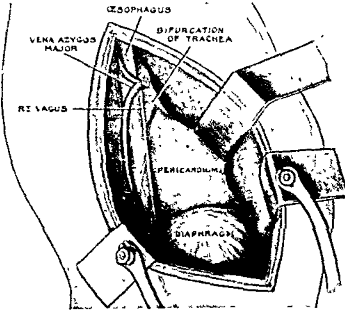

Fig. 2765.—Exposure of the thoracic œsophagus below the bifurcation of the trachea by the right transpleural approach. The right *lung is retracted forwards* and the œsophagus is seen lying between the bifurcation of the trachea, left bronchus, and pericardium anteriorly, and the vena azygos major posteriorly.
(*O'Shaughnessy and Raven. By courtesy of the "British Journal of Surgery."*)

accompanying blood-vessels is seen in the medial part of the wound; the vena azygos major is seen arching over the root of the lung to join the superior vena cava; the trachea is easily identifiable, and the right vagus may be found in a triangle bounded by the trachea, the vena azygos major, and the superior vena cava. The vena azygos major is divided and the mediastinal pleura incised to expose the œsophagus as it lies behind the trachea and above the right bronchus. In this way 8·5 cms. of the œsophagus may be exposed—the upper limit being the thoracic inlet and the lower limit the bifurcation of the trachea. The exposed œsophagus lies at a depth of 7·5 cms.

(2) *Right Transpleural Exposure of the Lower Œsophagus* (fig. 2766). The patient lies on the left side, with a pillow under the ribs and the right arm held by an assistant as in the operation of paravertebral

thoracoplasty. An incision is made over the 6th rib from the costal cartilage to the inferior angle of the right scapula. A subperiosteal resection of some 26 cms. of the 6th rib is then carried out. An incision is made in the 6th intercostal space and the pleural cavity opened. After lateral retraction of the right lung the following structures are seen anterior to the œsophagus: the bifurcation of the trachea, the left bronchus, the pericardium, and the diaphragm. Posteriorly are found the vena azygos major and the thoracic duct. Near the diaphragm the œsophagus becomes anterior to the descending

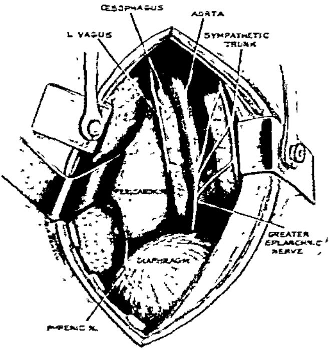

Fig. 2767.—Exposure of the thoracic œsophagus from the arch of the aorta to the diaphragm by the left transpleural approach. The left lung is retracted forwards and the œsophagus is seen lying between the descending thoracic aorta behind and the pericardium in front. The latter constitutes the greatest obstacle to clearance of the œsophagus.

(O'Shaughnessy and Raven. By courtesy of the "British Journal of Surgery.")

thoracic aorta, and above it is crossed by the vena azygos major. In this way the œsophagus is exposed between the lung root and the diaphragm in a length of 14 cms. Division and ligature of the azygos vein enable the organ to be followed up to a rather higher level, so that in all 16 cms. may be exposed. The œsophagus lies at a depth of 12 cms.

(3) *Left Transpleural Exposure of the Lower Œsophagus* (fig. 2767). The patient lies on the right side with a cushion beneath the ribs and the arm held by an assistant as for a paravertebral thoracoplasty. An incision is made over the 6th rib commencing at the costal cartilage and extending upwards and backwards over the inferior angle of the scapula. The periosteum covering this rib is elevated and 24 cms. of

the rib removed. The pleural cavity is opened through the 6th intercostal space. The left lung is retracted forwards and the œsophagus is identified lying between the descending thoracic aorta behind and the pericardium in front. The diaphragm is below, and in the inner part of the wound the termination of the left phrenic nerve with accompanying blood-vessels may be seen. The pericardium constitutes the greatest obstacle to clear vision, but after division of the mediastinal pleura the œsophagus may be drawn outwards and the left vagus with its plexus easily identified. In this way the œsophagus is exposed between the arch of the aorta and the diaphragm for a length of 14 cms. and at a depth of 9·5 cms.

(4) *Right Mediastinal Exposure of the Œsophagus* (fig. 2768). The patient lies prone on the table with the right arm held by an assistant

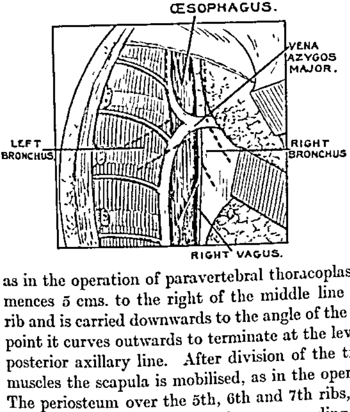

Fig. 2768.—Diagram to show the exact relations of the œsophagus at the level of the bifurcation of the trachea. The œsophagus lies posteriorly to the commencement of the left bronchus, and to a lesser extent it comes into contact with the commencement of the right bronchus

(O'Shaughnessy and Raven. By courtesy of the "British Journal of Surgery")

as in the operation of paravertebral thoracoplasty. The incision commences 5 cms. to the right of the middle line at the level of the 2nd rib and is carried downwards to the angle of the right scapula, at which point it curves outwards to terminate at the level of the 8th rib in the posterior axillary line. After division of the trapezius and rhomboid muscles the scapula is mobilised, as in the operation of thoracoplasty. The periosteum over the 5th, 6th and 7th ribs, together with the tips of the transverse processes of the corresponding vertebræ, are removed. The lengths of ribs removed are: 5th rib, 7·5 cms.; 6th rib, 8·5 cms.; 7th rib, 7·5 cms. The parietal pleura is gently separated from the vertebral bodies in a downward direction until the œsophagus is exposed lying between the vertebral column and the separated lung and pleura. The lung and pleura are on the right of the œsophagus, and the bodies of the vertebræ are on the left; in front is the trachea and the left bronchus, and at the actual bifurcation of the trachea the commence-

ment of the right bronchus also forms an anterior relation. The vena azygos major passes upwards on the left margin of the œsophagus and at the level of the root of the right lung passes behind the œsophagus to join the superior vena cava. The right vagus nerve is seen on the right of the œsophagus giving a well-marked branch to the posterior aspect. In this way 8 cms. of the œsophagus may be exposed at a depth of 6·5 cms.

(5) *Left Mediastinal Exposure of the Lower Œsophagus* (fig. 2769).

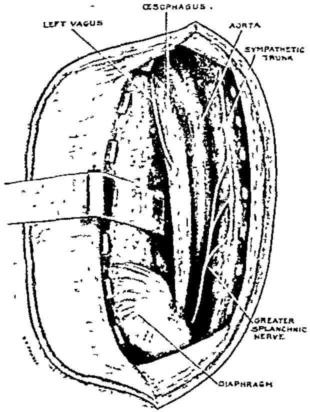

Fig. 2769.—Exposure of the thoracic œsophagus from the arch of the aorta to the diaphragm by the left mediastinal approach. The parietal pleura is separated from the vertebral bodies in a downward direction, and the œsophagus is exposed between the separated lung and pleura and the descending thoracic aorta.

(O'Shaughnessy and Raven. By courtesy of the "British Journal of Surgery")

The patient is placed prone on the table with the left hand held above the head by an assistant. The incision commences at the level of the 3rd rib, 3 finger-breadths below the mid-line, and extends vertically downwards until it takes an outward sweep along the axis of the 11th rib. The periosteum covering the posterior aspects of the 4th to 11th ribs is exposed and elevated, and 6 cms. of each rib is removed. The length removed diminishes towards each extremity of the wound. The parietal pleura is gently separated in a downward direction, commencing near the mid-line. The œsophagus lies between the separated

lung and pleura and the descending thoracic aorta. To the inner side of the aorta the bodies of the thoracic vertebræ may be seen with the thoracic trunk of the sympathetic and the great splanchnic nerve. The œsophagus disappears above under the arch of the aorta, and, below, it may be seen passing through the œsophageal hiatus of the diaphragm. In this way the œsophagus may be exposed from the arch of the aorta to the diaphragm for a length of some 14 cms. A similar incision but with the sacrifice of fewer ribs permits of a more limited exposure. The œsophagus lies at a depth of 7·5 cms.

The Abdominal Œsophagus.

Reference has already been made to the successful operation by Grey Turner in which a carcinoma of the œsophagus was extirpated by the collo-abdominal route. His abdominal approach was made through a median incision, and, after separation of the left lobe of the liver from the diaphragm, the œsophagus was exposed.

A carcinoma of the lower œsophagus was excised by Gohrbrandt from below the diaphragm and continuity was restored. The abdomen was opened by an oblique incision below the left costal border. The cardiac end of the stomach was drawn towards the surface, and after section of the left vagus and transverse division of the peritoneum a blunt separation of the lower end of the œsophagus was carried out. Free mobilisation was only possible after section of the right vagus. Gohrbrandt recommends that separation should be carried out by the index finger rather than by any special form of instrument, in order to avoid an accidental wound of the pleura as the viscus is followed into the mediastinum. Grey Turner has also used this method. Clairmont has employed this route for the excision of an epiphrenal diverticulum. Grey Turner has made use of the abdominal approach for the operation of œsophago-gastrostomy in cases of cardiospasm and simple stricture, and a similar approach has been used by Fromme.

Technique.

(1) *Simple Laparotomy.* The patient lies on his back in the reversed Trendelenburg position—that is, with the foot of the table inclined downwards. A median incision from the ensiform to the umbilicus serves to open the abdominal cavity. After division of the left lateral ligament the left lobe of the liver may be retracted to the right and the region of the cardia exposed. The stomach is drawn downwards and the abdominal œsophagus comes into view. After transverse division of the peritoneum blunt dissection, followed by gentle traction, renders it possible to expose some 5 cms. of the œsophagus at a depth of 13 cms.

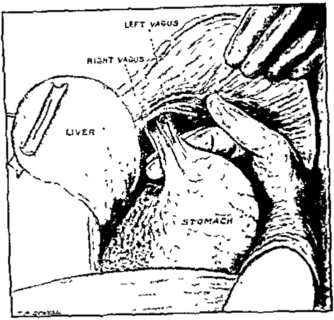

Fig 2770.—Exposure of the abdominal œsophagus by the Marwedel method. The left lobe of the liver has been mobilised to the right and the hinged flap consisting of the lower ribs has been turned upwards and outwards and the abdominal œsophagus is lifted to the surface.

(O'Shaughnessy and Raven. By courtesy of the "British Journal of Surgery.")

(2) *Marwedel Method* (modified) (fig. 2770). The patient lies in the reversed Trendelenburg position, and a vertical incision is made from the root of the ensiform process to a point 2 cms. below the umbilicus. At the juncture of the upper two-thirds and lower one-third of this line a second horizontal incision passes out to the costal border. A triangular musculo-cutaneous flap is dissected upwards to expose the lower costal cartilages on the left side. After section of the 6th and 7th costal cartilages at their junction with the sternum a subperiosteal resection of some 2 cms. of the 7th, 8th and 9th ribs at the costochondral junction is carried out.

This manœuvre enables the left costal border to be lifted up in the manner of a trap-door, and after division of the left lateral ligament and retraction of the left lobe of the liver an excellent exposure of the œsophagus is obtained. In this way, after division of the peritoneum, mobilisation of the œsophagus, and section of both vagi, some 8 cms. of the œsophagus may be exposed. The original depth from the surface is 14 cms., but mobilisation of the organ, together with retraction of the costal flap, enables the œsophagus to be brought up almost to the surface of the wound.

In approaching the œsophagus by the transpleural route in the dissection, rib resection was always practised. A similar exposure may be obtained by an intercostal incision with removal of segments of the ribs posteriorly, as practised by Lilienthal, or by division of the costal cartilages anteriorly, as done by Kirschner.

The upper œsophagus—from the level of the thoracic inlet to the lung root—is best exposed by a right transpleural approach.

The *œsophagus in the region of the lung root is* best exposed by a right mediastinal approach. Excision of short segments of rib renders adequate exposure difficult, but if the lengths described are excised, there is ample room for the assistant's hand to retract lung and pleura without encroachment on the operative field. It is also possible to expose this region by a right transpleural approach after ligature and division of the azygos vein.

The lower œsophagus—from the level of the aorta to the œsophageal hiatus in the diaphragm—is best exposed by a left transpleural approach. *If there is any doubt as to the upper limit of the lesion, the right trans*-pleural approach should be substituted, because ligature and division of the vena azygos major enables the organ to be followed upwards, while separation of the œsophagus from behind the arch of the aorta is an intervention of great magnitude. It is also possible to expose the lower œsophagus by the mediastinal route, and here also approach from the left side is to be preferred.

Approaching the œsophagus from below, the modified Marwedel *incision seems to be the method of choice if a difficult operation such* as local resection with restoration of continuity is contemplated. In suitable cases the operation could be carried out in two stages, with mobilisation of the costal arch as the first.

THE TECHNIQUE OF OPERATIONS ON THE ŒSOPHAGUS

(1) Resection of the thoracic œsophagus.
(2) Operative treatment of cardiospasm, including œsophago-gastrostomy.
(3) Œsophagoplasty.

Technique of Œsophageal Resection

The approach and mode of operation differs according to the site of the growth, and for this purpose the œsophagus may be divided into three zones:

Zone 1. Thoracic inlet and downwards for 2 or 3 cms.
Zone 2. Thoracic inlet to bifurcation of trachea.
Zone 3. Bifurcation of trachea to cardia.

Resection at the Thoracic Inlet (Collar Resection)

A gastrostomy is carried out some two weeks before radical operation is attempted. A large collar incision exposes the region above the

jugular notch and clavicles. The œsophagus is exposed on the left side, as described under the heading of Cervical Œsophagostomy. The œsophagus is followed down into the posterior mediastinum and separated from its surroundings by blunt dissection. With care it should be possible to avoid wounding the mediastinal pleura, but in case of this accident positive pressure anæsthesia must be at hand.

The tumour having been isolated, a crushing clamp is placed below it and a strong silk ligature applied. After clamping the oral end, the œsophagus is divided by the cautery and displaced upwards into the neck. If practicable, the aboral end is invaginated and secured by suture. The oral end of the œsophagus is separated upwards until it can be brought out on the surface of the neck without tension, and to facilitate this step a vertical skin incision may be made, beginning at the centre of the original incision. The mediastinum is packed with gauze and the wound partially closed. Before applying the final dressing, a tube must be secured in the oral œsophagus to prevent soiling by saliva and secretion from the growth.

Ten days must elapse before the tumour is extirpated, as this period enables protective granulations to develop in the wound area. In an exceptionally favourable case, the problem of restoring continuity may be met by an ante-thoracic œsophagoplasty, but usually a rubber tube connecting the cervical œsophagus to the gastrostomy opening must suffice. The possibilities of this method are illustrated by the very remarkable case reported by Evans.

Resection between the Thoracic Inlet and the Bifurcation of the Trachea

The transpleural operation (figs. 2771, 2772 and 2773). A right transpleural exposure under positive pressure anæsthesia is carried out as already described. Access to the œsophagus is obtained by careful incision of the mediastinal pleura. The œsophagus is freed from its bed by blunt dissection with the finger, and during this procedure it may be found that extension of the growth makes separation impossible so that the operation must be suspended and the chest closed in the usual way.

When separation has been effected, a rubber tube is passed round the œsophagus to facilitate its manipulation, and the organ is divided below the growth with the usual precautions, the aboral stump being closed and allowed to drop back into the wound. To enable treatment of the oral end the incision must be extended into the neck, and the procedure is then completed as in collar resection,

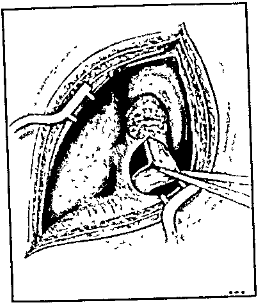

Fig. 2771.—Transpleural resection of carcinoma of the œsophagus.
(*Modified from Torek.*)

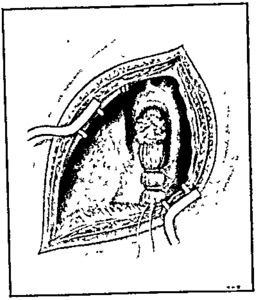

Fig. 2772.—Transpleural resection of carcinoma of the œsophagus.
(*Modified from Torek.*)

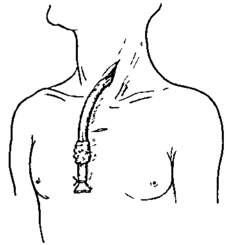

Fig. 2773.—Transpleural resection of carcinoma of the œsophagus.
(*Modified from Torek.*)

while the problem of restoring continuity must be dealt with in a similar way.

After inflation of the lung, the pleural cavity is closed in the usual manner.

The extra-pleural approach. Stage 1. Approach may be from either side and the incision marks out a suitable flap for the subsequent œsophagoplasty. Access to the posterior mediastinum is gained as already described. The lung and pleura are retracted outwards and the œsophagus, having been freed from its bed, is drawn towards the surface. Ligature of the azygos vein may be required and all hæmorrhage in the œsophagus bed must be controlled. The skin flap is passed

underneath the œsophagus, to which it is secured by a few stitches, and the wound is packed with gauze and partially closed by suture (figs. 2774, 2775, 2776 and 2777).

Stage 2. This follows some 12 days later. The growth, together with a suitable portion of the œsophagus, is excised.

Stage 3. Some 4 weeks later, by suitable incision and suture, the skin flap is converted into a tube which serves to restore continuity.

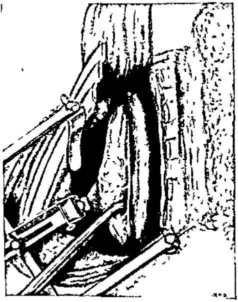

Fig. 2774.—Excision of the œsophagus by the mediastinal route.

(*After Lilienthal. Reproduced from Abel's "Œsophageal Obstruction," Oxford Univ. Press, 1929.*)

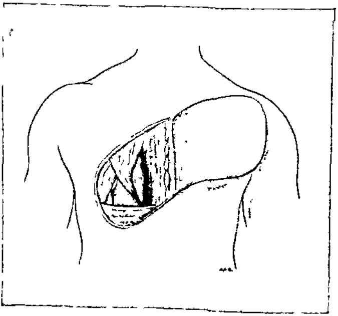

Fig. 2775.—Excision of the œsophagus by the mediastinal route. (*Abel.*)

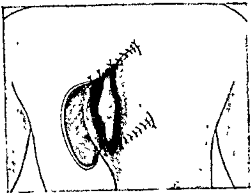

Fig. 2776.—Excision of the œsophagus by the mediastinal route. (*Abel*)

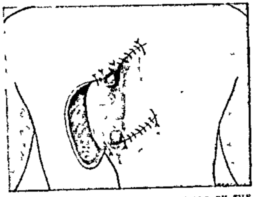

Fig. 2777.—Excision of the œsophagus by the mediastinal route. (*Abel*)

Resection at the Bifurcation of the Trachea

The method just described may be used for growths at the level of the bifurcation of the trachea, but here approach is easier from the left side. In this approach the aorta is encountered, and the various direct branches from it to the œsophagus must be ligated with care. In general, the technique is similar to resection of the upper œsophagus by the extra-pleural method.

Lilienthal in his successful case operated somewhat after this manner.

Resection of the Lower Third of the Thoracic Œsophagus

Transpleural approach. A preliminary jejunostomy is to be preferred to a gastrostomy in order to leave the stomach free for its mobilisation and dislocation into the thorax. A left transpleural approach is carried out as previously described.

The phrenic nerve is crushed, and the peritoneal cavity is entered by careful incision of the diaphragm. This incision should reach from the cardia to the 12th rib, and suitable retraction displays the contents of the upper left abdomen to view. The stomach is freed by ligature and division of the vessels of the greater and lesser omenta by the Kirschner method, which is described on page 5095. The vagi are divided in order that one important path for nociceptive impulses may be broken. The œsophagus is separated from its bed by blunt dissection and, after application of strong clamps and ligatures, the segment containing the growth is excised. The aboral end is invaginated into the stomach and secured by sutures, while the oral end is retained for implantation into the stomach.

After careful isolation by gauze packs and aspiration of the stomach contents by puncture, that viscus is displaced upwards until a suitable site for union with the œsophagus can be selected without undue tension. The œsophagus is sutured to the stomach just above the point

on its anterior surface selected for the anastomosis, and two incisions are made through the stomach wall. The upper incision must be some 2·5 cms. long while the lower incision, situated some 5 cms. below the first, need only be large enough to admit a pair of ligature forceps.

Fig. 2778.—TRANSPLEURAL RESECTION OF THE LOWER ŒSOPHAGUS.
(*After Lilienthal. Reproduced from Abel's "Œsophageal Obstruction."*)

Fig. 2779.—TRANSPLEURAL RESECTION OF THE LOWER ŒSOPHAGUS.
(*After Lilienthal. Reproduced from Abel's "Œsophageal Obstruction."*)

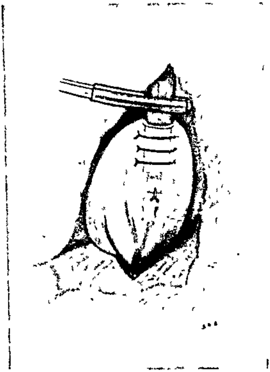

Fig. 2780.—Transpleural resection of the lower œsophagus.
(*After Lilienthal. Reproduced from Abel's "Œsophageal Obstruction."*)

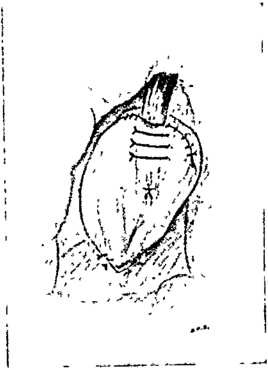

Fig 2781.—Transpleural resection of the lower œsophagus.
(*After Lilienthal. Reproduced from Abel's "Œsophageal Obstruction"*)

The forceps are then passed into the stomach through the small incision and out through the large incision in order to grasp the ligature closing the oral end of the œsophagus, which is then drawn down into the stomach. By traction on the forceps an assistant holds the œsophagus in place while a series of single sutures secures the anastomosis line. Three tiers of Lembert sutures should, if possible, be inserted, uniting the gastric serosa to the muscle of the œsophageal wall. On completion of the anastomosis the œsophageal ligature is withdrawn from the lower stomach wound. It is divided, and the wound closed by suture. The stomach is sutured to the edges of the cut diaphragm, and the chest closed (figs. 2778, 2779, 2780 and 2781).

Although excision and restoration of continuity within the thorax is the obvious ideal, in most cases it has only been possible to close the lower end of the œsophagus and then, after blunt separation of the organ from the mediastinal structures, to remove it, together with the tumour, through a second incision in the neck. The patient is then left with a cervical œsophagostomy and a gastrostomy. Somewhat after this manner Zaaiger operated with success for a tumour which required resection of the lower end of the œsophagus together with the cardiac part of the stomach. He made a preliminary gastrostomy at the

pyloric end of the stomach and did not attempt to restore continuity by anastomosis. The oral end of the œsophagus, together with the tumour area, was brought to the surface, so that the patient remained with a gastrostomy and an œsophageal fistula at the level of the 8th rib: soft foods could be ingested and pass between these two points through a rubber tube. A similar success has been recorded by Muir.

Extra-pleural approach. Dislocation of the stomach is also possible by an extra-pleural method after resection of the lower ribs and transverse processes. The operation is one of great severity, and, although its design in some ways represented a technical advance, a successful operation on man by this route has not been recorded.

The technique of collo-abdominal resection of the œsophagus has been described in recent papers by Grey Turner, and in his hands the operation has proved practicable and successful. A deliberate exposure of the thoracic œsophagus is avoided. In the case of growths of the lower œsophagus. after exposure of the abdominal œsophagus as already described, a blunt dissection is carried out through the œsophageal hiatus as far upwards as is practicable. and the œsophagus is then severed at the cardia. The œsophageal hiatus is closed by suture of the left lobe of the liver. The cervical œsophagus is next exposed and followed downwards into the mediastinum by a similar process of dissection. Finally the entire organ. together with the tumour, is withdrawn from the neck wound. It is recommended that the organ should be left *in situ* for a few days before its final removal.

Technique of the Operative Treatment of Cardiospasm

Exposure of the Cardia.

A long incision is made in the left 9th intercostal space and a suitable retractor inserted. Additional access may be obtained by division of the costal cartilages in front or of the posterior end of the adjoining ribs behind. Inflation of the lung is maintained by positive pressure anæsthesia, and retraction of the left lower lobe exposes the area. Any obvious abnormality, such as adhesions causing local distortion or hypertrophy of the diaphragmatic sling, is dealt with; otherwise Heller's operation, cardioplasty or œsophago-gastrostomy must be undertaken. Crushing of the phrenic nerve is an essential preliminary in all three cases.

Heller's Operation.

Transpleural route. Exposure of œsophagus as described. A small lappet of diaphragm immediately in front of the hiatus œsophagi is seized with artery forceps, and the peritoneal cavity cautiously opened.

The forefinger is passed through this opening in the diaphragm up to the cardia and the overlying fibres are divided. Mobilisation of the cardio-œsophageal junction is now possible, and a vertical incision some 6 cms. long is made through the muscle coats, care being taken to avoid injury to the mucosa. This wound is not sutured. The incision in the diaphragm is closed so that the incised portion of œsophagus comes to lie beneath the diaphragm. The chest wound is closed in the usual way.

The chief risk of this intervention is encountered during the mobilisation of the œsophagus. Incautious manipulation in the presence of adhesions may result in a tear of the œsophageal wall. Such a tear may be so minute as to escape immediate notice but sufficient to determine a fatal mediastinitis in the course of a few days.

Transperitoneal route. The cardia is exposed by a mid-line incision and by blunt dissection of the hiatus œsophagi a sufficient length of œsophagus (about 6 cms. in all) is exposed to permit of incision as just described. The abdominal incision is closed in the usual way. As the mediastinal pleura may often be wounded during this intervention, positive pressure anæsthesia should be at hand.

Cardioplasty.

The cardia is exposed and a vertical incision made, as in Heller's operation, but deep enough to include the mucosa. To prevent soiling, fine clamps are applied above and below the line of incision. The vertical incision is then repaired by transverse sutures as in the operation of pyloroplasty.

Œsophago-gastrostomy.

The cardia is exposed as in Heller's operation, but a rather larger opening in the diaphragm is required and the œsophagus need not be mobilised behind as in that procedure. A suitable portion of the anterior surface of the fundus of the stomach is isolated by clamps and approximated to the anterior surface of the œsophagus 2–3 cms. above the cardia. Anastomosis is carried out as in gastro-enterostomy. A fold of stomach sutured over the line of anastomosis gives increased security. The wounds in the diaphragm and chest wall are closed in the usual way.

The operation may be done in two stages and the anastomosis completed in the second stage. The adhesions which form at the first operation, while increasing the immediate difficulty of the second stage, tend to limit any infection which may result from opening into the œsophageal lumen.

Œsophagoplasty.

Bircher in 1894 was perhaps the first to attempt a planned œsophagoplasty. His method was based on the von Hacker operation for substitution of the cervical œsophagus. A long tube was fashioned from the skin of the anterior chest wall and this tube anastomosed to the stomach. The passage was patent and conducted fluids into the stomach, but the patient died from a pulmonary embolus before the final stage—union of the skin tube with the cervical œsophagus—could be carried out. Following this, Wullstein proposed that an isolated loop of jejunum should be employed and that the lower end of this loop should be joined to the small intestine and not to the stomach. Three years later Roux modified and improved the technique, and the first completed case was done by Herzen some years later. In his case a portion of jejunum was isolated and, after continuity of the small intestine had been restored, this segment was brought out of the abdomen and transplanted beneath the skin of the anterior thoracic wall. A junction was then effected with the cervical œsophagus above and the stomach below. von Hácker and others published accounts of similar operations in which a portion of large gut was used in place of jejunum. Roith carried out an operation of this type in one stage and the patient was able to swallow normally after a period of three weeks. Lexer introduced a further modification in which, in place of a direct anastomosis between the cervical œsophagus and the intestine, a skin tube was fashioned to bridge the gap and so avoid any undue tension on the mesentery.

Attempts were also made to fashion a tube from the greater curvature of the stomach, but without success. Dengel has recently published a case in which the tube was furnished by the lesser curvature and his patient was healed.

Although the literature contains more than a hundred accounts of the operation of ante-thoracic œsophagoplasty, the number of encouraging results is small. Fistulæ are apt to form at the sites of anastomosis, and too often the patient must suffer a series of plastic operations in order to be maintained in even passable comfort. A very brilliant operative success has recently been recorded by Sampson.

The possibility of utilising the stomach itself to replace an obliterated passage was early explored by Enderlen, Brun and Henschen. The stomach was divided at the pylorus and the pyloric end turned upwards in such a way as to effect union with the cervical œsophagus, while a second anastomosis between the cardiac end of the stomach and jejunum restored continuity of the alimentary canal.

More recently Kirschner has developed this principle further, with the important difference that in his operation the stomach is cut across at the cardia and the organ is then dislocated, so that the cardiac end of the stomach comes to the level of the collar bone. The only vascular supply remaining to the stomach is from the vessels at the pyloric end—the right gastric and right gastro-epiploic arteries. Brun had early affirmed on the ground of anatomical research that such displacement of the stomach should be possible, and Miller and Andrus on experimental grounds that adequate mobilisation is possible even if the left gastro-epiploic artery be spared. Kirschner has carried out this operation twice for simple stricture; one patient recovered, and one died fourteen days later from a phlegmonous inflammation of the thoracic œsophagus which was not connected with the operation site. Kirschner's operation is an important technical advance; its main disadvantage is the difficulty of dealing with the lower end of the severed œsophagus. Anastomosis to the jejunum is a laborious procedure, yet it is essential that drainage of the lower œsophagus should be obtained.

Œsophago-jejuno-gastrostomy (figs. 2782, 2783 and 2784).

The question of a preliminary gastrostomy must be decided in each case. A gastrostomy may hinder subsequent operative manœuvres, but no plastic operation is likely to succeed in a starving patient.

Stage 1. Under general narcosis the abdomen is opened through a median incision commencing at the xiphoid process. A suitable loop of jejunum, some 30 cms. from the plica duodeno-jejunalis, is selected and the suitability of its mesentery for the proposed dislocation assessed. To form the skin tunnel a transverse incision, 10 cms. in length, is made through skin and subcutaneous tissue at right angles to the upper end of the abdominal wound, and a second incision parallel to this at the level of the jugular notch. By means of blunt dissection, communication is established between these two incisions and the resultant tunnel is packed with a strip of gauze. A loop of jejunum, 25–30 cms. in length, is now excluded and continuity restored by end-to-end anastomosis. Mobility of the mesentery may be increased by a few cautious incisions, care being taken to spare the blood-vessels. The loop is now displaced into the upper abdomen through a slit in the transverse mesocolon and the gastro-colic omentum. An anastomosis between the lower end of the loop and the cardiac end of the stomach is carried out in the usual way. A long silk ligature is passed from the jugular end of the tunnel and fastened to the oral end of the loop, which is then drawn up through the tunnel and fixed with a few sutures at its upper end. The abdominal wound is now closed in layers, due

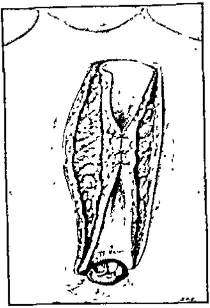

Fig 2782.—Drawing showing formation of cutaneous tube by means of parallel incisions through the skin of the anterior thorax. The skin flaps so mobilised are sutured in such a way that the cutaneous surface lines the tube on the inside. At the lower portion of the drawing the upper end of the jejunal loop is visible.

(*After Ochsner and Owens. By kind permission of "Annals of Surgery."*)

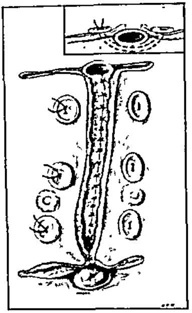

Fig 2783.—Drawing showing the covering of the skin tube by mobilisation of the lateral skin edges on either side. Retention sutures are placed over buttons, the sutures passing deep to the œsophagus in order that pressure on the œsophagus may be avoided. Closure of the skin covering the newly formed skin tube. The upper end of the jejunum is visible.

(*After Ochsner and Owens. By kind permission of "Annals of Surgery."*)

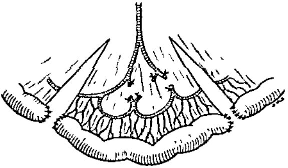

Fig. 2784.—Method of mobilising jejunum.

(*After Torek. "Nelson's Surgery."*)

care being taken to avoid strangulation of the mesentery of the dislocated loop. The final step is to provide the tunnel with some tension incisions. These should be vertical, 2 cms. in length, and placed at intervals along both sides of the tunnel.

Stage 2. An interval of some weeks is needed to complete convalescence from Stage 1. The union between the cervical œsophagus and the dislocated loop may be effected under local anæsthesia.

With the head in fullest extension, an incision is made along the anterior border of the left sterno-mastoid muscle, and the attachment of this muscle to the clavicle is divided. The muscle is retracted outwards, the trachea and thyroid gland inwards, and the œsophagus is exposed in some 10 cms. of its extent, as far down into the thorax as is possible. Clamps are applied and the œsophagus is cut across. The aboral end is ligated, invaginated by two layers of sutures, and dropped back into the wound. If there is any doubt as to the adequate closure of the stump, a gauze pack must be left in position till the following day. The head is flexed so as to approximate the oral end of the severed œsophagus to the upper end of the dislocated loop. An end-to-end anastomosis is now carried out, with a preliminary freshening of the edges of the intestine. The wound is closed, a drain left in position, and plaster-of-Paris bandages applied so as to maintain full flexion of the head.

Œsophago-dermato-jejuno-gastrostomy.

Stage 1. Mid-line incision followed by isolation and displacement of the jejunal loop as in œsophago-jejuno-gastrostomy. Implantation of the oral end of the loop into the anterior wall of the stomach, and closure of the aboral end. The closed end of the jejunal loop is withdrawn from the upper angle of the wound, embedded in a subcutaneous tunnel made on the same principle as in the previous operation, and secured in place by one or two sutures. The abdominal wound is closed with the usual precautions as to the mesentery.

Stage 2. Three weeks later the skin tube is prepared. Two vertical and parallel incisions beginning at the centre of the left clavicle and at the jugular notch are carried down to the level of the displaced jejunal loop. By dissection it is possible to roll the edges of the strip so outlined round a long rubber tube and by suture to fashion a skin tube. The edges of the long wound left on each side may be undercut and brought together over the new canal. If tension is feared, the defect may be covered by Thiersch grafts.

Stage 3. Anastomosis of the skin tube with the jejunal loop.

Stage 4. Anastomosis of the skin tube with the cervical œsophagus.

Œsophagoplasty—Kirschner's Method (see fig. 2785).

The following is an abbreviation of Kirschner's account of his operation:

Stage 1. The abdomen is opened by a long incision parallel with the left subcostal margin. The wound is widely retracted and, if need be, the 7th costal cartilage is divided.

Stage 2. Mobilisation of the stomach. The fundus and body of the stomach are carefully separated from their peritoneal connections. Ligatures are placed at a little distance from the edges of the stomach in order to preserve any local anastomosis. This step involves ligature of the left gastric and left gastro-epiploic arteries and of the vasa brevia. The stomach is cut through 4 cms. below the cardia, drawn out of the abdominal wound and wrapped in a warm saline pack.

Stage 3. Œsophago-jejunostomy. The jejunum is cut across some centimetres below the duodeno-jejunal flexure. The oral end of the jejunum is closed by suture and continuity restored by an end-to-end

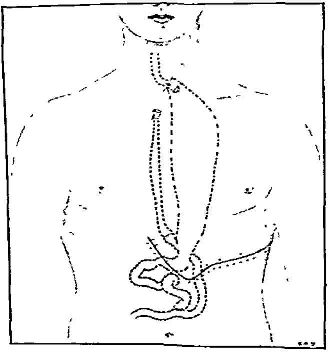

Fig. 2753.—Œsophagoplasty. (*After Kirschner.*)

anastomosis with the remaining jejunum 25 cms. below the point of section. The aboral end of the divided jejunum is brought up through the mesocolon and anastomosed to the stump of the cardiac end of the stomach by means of a Murphy button.

Stage 4. Ante-thoracic subcutaneous dislocation of the stomach. The patient's body is flexed forwards. The stomach is brought up over the left subcostal margin until it reaches the left side of the neck, and the point which it reaches without undue tension is marked with a skin pencil. A transverse incision is now made at the marked site and a subcutaneous tunnel constructed with blunt scissors and forceps between this point and the abdominal wound. Into this tunnel the stomach is drawn up and secured by suture.

Stage 5. Closure of abdominal wound. Carried out in the usual way except that the stomach is secured by interrupted sutures to the parietal peritoneum at its exit.

Stage 6. As soon as mobilisation of the stomach is determined upon, a second group of operators expose the cervical œsophagus, cut it across, and prepare to anastomose the oral end to the dislocated stomach once it is in position. This anastomosis is completed and the wound closed.

Following the operation the patient must be maintained in the flexed position, and food per os is withheld for some days. Morphia and atropine in adequate dosage serve to hinder undue secretion from the transplanted intestine.

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SECTION 2

SURGERY OF THE DIAPHRAGM

HISTORICAL

THE earliest detailed account of a diaphragmatic lesion is by *Ambroise Paré* (1510–1590) who records the post-mortem findings in a man who died from a strangulated diaphragmatic hernia some months after his recovery from a severe sword wound of the chest.

Petit (1674–1750) wrote of his dissections of congenital diaphragmatic hernia, and in 1769 *Morgagni's* treatise on diaphragmatic hernia was published. There are other references to hernia in the literature of the eighteenth century, but it was the clinical material provided by the French wars which enabled *Guthrie* to make the first practical contributions to the surgery of the diaphragm. Guthrie recognised that large incised wounds of the diaphragm did not heal, and he records the death from strangulation of a diaphragmatic hernia of a dragoon who, having suffered a penetrating sword wound of the chest at Waterloo, was seized with his fatal attack while grooming a horse. Guthrie proposed that such an accident should be treated by abdominal section, incision of the neck of the sac and reposition of the viscera, and in the succeeding century this was attempted on various occasions but without success. *Paget* in 1896 could find records of 300 cases of hernia; in only seven had the diagnosis been made during life and there had been only two successful operations, both carried out by the transpleural route.

The invention of radiology, the use of differential pressure anæsthesia, and the abundant clinical material provided by the Great War finally established the surgery of the diaphragm on a firm basis.

ANATOMY

Arising from the margins of the thoracic outlet, the diaphragm forms a muscular septum between the thoracic and abdominal cavities. Of surgical importance are the apertures through which pass various structures such as the aorta, and also those intervals between the three divisions of the organ—sternal, costal, and lumbar—in which a relative deficiency of muscular fibres allows pleura and peritoneum to come into so close a relation that infective processes may readily pass from one sac to the other.

The œsophageal hiatus is situated in the muscular part of the diaphragm at the level of the 10th dorsal vertebra. The aortic hiatus is at the level of the 12th

dorsal vertebra and serves to transmit the aorta, azygos veins and thoracic duct. The caval orifice is in the central tendon at the level of the 8th dorsal vertebra. Each crus is perforated by the greater and lesser splanchnic nerves (figs. 2786 and 2787).

The important superior relations of the diaphragm are the pleura on each side

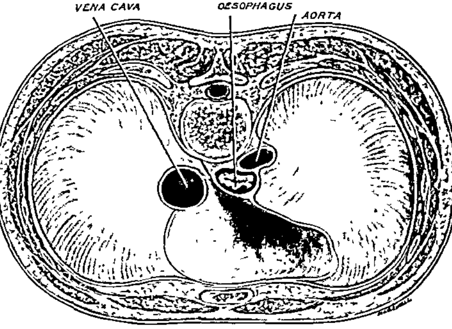

Fig 2786.—The diaphragm as seen from above.

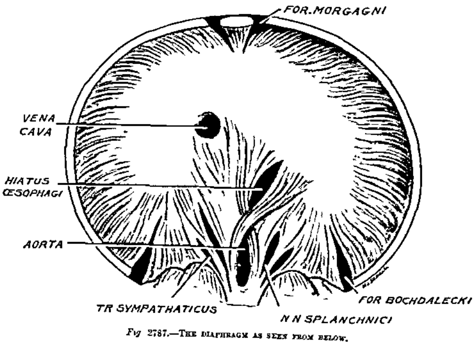

Fig 2787.—The diaphragm as seen from below.

and the pericardium in the centre. Below on the right lies the liver together with the adrenal and upper pole of the right kidney, and on the left the stomach, spleen, left kidney and adrenal. Peritoneum invests the greater part of this surface.

Vascular Supply.

The following arteries supply the diaphragm: superior phrenic, inferior phrenic, intercostal, musculophrenic and pericardiacophrenic.

The phrenic arteries are direct branches of the aorta, the superior arising immediately above the hiatus and the inferior immediately below. Branches from the last five intercostal arteries enter the diaphragm to anastomose with branches of the other vessels described. The musculophrenic is the largest artery of supply; it is one of the terminal branches of the internal mammary artery and it pursues a lateral course in relation to the costal origin of the muscle. The pericardiacophrenic artery reaches the diaphragm together with the phrenic nerve.

Nerve Supply.

The phrenic nerve arising from the 3rd, 4th and 5th cervical segments is responsible for the nerve supply of the diaphragm. Recent work (Jansen) does not

Fig. 2788.—Atrophy of the diaphragm following phrenic evulsion.
(*Drawn from a specimen in Mr. G. A. Mason's private collection.*)

support the view that the intercostal nerves supply part of the costal origin or that the crus may receive some supply from the lumbar plexus. The importance of the accessory phrenic was first established by Felix and is now generally realised.

The researches of Aoyagi, Felix and others have demonstrated the anatomical importance of the sympathetic component of the phrenic nerve, but the clinical significance of these fibres remains a subject for debate. At the same time, it seems probable that they play some part in the regulation of respiratory movement and are concerned in the phenomenon of singultus. The pleura and peritoneum which cover the centre and posterior portions of the diaphragm receive a sensory supply from the phrenic; at the periphery the supply is from the lower five intercostal nerves. Figure 2788 depicts atrophy of the diaphragm following phrenic evulsion.

The Lymphatics of the Diaphragm.

Kuttner has described the intricate lymphatic plexus of the diaphragm which is found on both surfaces under the serous coat. There are many connections between the subpleural plexus and that which lies under the peritoneum. Some of the efferent channels terminate directly in the thoracic duct, while others pass to the mediastinal glands.

APPLIED PHYSIOLOGY

The function of the diaphragm may be considered under four headings: Its respiratory function is of the greatest importance; the diaphragm forms a complete barrier between the thoracic and abdominal cavities; normal diaphragmatic movement is essential for the proper regulation of the circulation; and the diaphragm also plays a role in preserving normal gastro-intestinal function.

The diaphragm is a muscle of inspiration, and under normal circumstances its excursion is very small—not more than half an inch. During exercise the range of its movements is increased. and it seems probable that athletes acquire exceptional control of the muscle It is interesting to note that the most recent investigations of diaphragmatic function using the new radiological technique of kymoscopy (Weber) confirm the original view of Keith that aeration of the lower lobe of the lung is the special function of the diaphragm. The detailed mechanics of the muscle and its relation to abdominal pressure below and to pleural pressure above are still under investigation. and it cannot be claimed that sufficient finality has been reached to allow of clinical application of the principles involved. It is clear that diaphragmatic function is to be preserved if possible, and the modern tendency is to attribute many post-operative lung complications to diminution in its normal movement.

A breach in continuity of the diaphragm, whether of congenital or acquired origin, permits the escape of the more mobile abdominal viscera into the chest, and the serious or even fatal complications which may attend this event are discussed in detail below.

Wenckebach, Eppinger and others have stressed the importance of the muscle in maintaining, or rather encouraging, the flow of blood from the abdomen to the right heart. It has been established that the caval hiatus and the aortic opening remain equally patent at all stages of diaphragmatic movement. Nissen and Wustmann showed in some ingenious experiments that the passage of an artificial embolus above the inferior vena cava was delayed by paralysis of the diaphragm.

The diaphragm is of importance in such acts as parturition when, with a closed glottis, it helps to increase the abdominal pressure. Eppinger suggests that it has an influence on the gall passages, as well as on colonic peristalsis, but at present there seems scant experimental or clinical evidence to support this view.

The diaphragm is normally in a state of tonus, which is said to be controlled by the sympathetic nerve supply. Ken Kuré has given clinical and experimental grounds for this belief and, whatever may be the final result of his investigation, he has demonstrated that the diaphragm provides an excellent field for the comparison of cerebro-spinal and sympathetic nerve impulses.

The diaphragm plays no active part in the act of coughing, and indeed in certain diseases, such as basal bronchiectasis, induced paralysis of the diaphragm assists expectoration.

The singular phenomenon of singultus is due to clonic spasm of the diaphragm. The mechanism seems clear when there exists an inflammatory focus in the mediastinum near the phrenic stem, and irritation of the terminal filaments of the nerve may account for singultus in the course of peritonitis affecting the upper abdomen. Singultus associated with disease of the urogenital system or

with infections such as influenza can only be explained by postulating some effect on the respiratory centre itself. Singultus of central origin can be controlled by blocking the phrenic nerves in the neck. If the cause lies within the thorax or upper abdomen this measure is useless, and oral administration of cocaine and similar drugs must be employed.

In tetanus the determining cause of death may be a tonic spasm of the diaphragm, which not only hinders normal respiration but renders attempts at artificial respiration futile. It was in such a case that Sauerbruch sectioned both phrenic nerves and so induced total paralysis of the diaphragm. The patient survived and eventually returned to a normal life at school. This case provided *startling evidence of the natural power of compensation, and since this date total* paralysis of the diaphragm has been induced in cases of pulmonary tuberculosis (the writer recorded four such operations in 1931) and the elimination of one leaf of the diaphragm from active function has become a common therapeutic measure. At the same time evidence has recently accumulated to show that in later life paralysis of the diaphragm is a functional handicap and in a more recent paper (1935) the advantages of a temporary rather than a permanent therapeutic paralysis are discussed.

RADIOLOGICAL EXAMINATION

Examination with the fluoroscope shows that the normal range of movement is only 1–2 cms., which on deep breathing increases to 2–4. Only in the deepest inspiration does the central tendon partake in this movement. Paralysis of the diaphragm is indicated by a higher level and by absence of the normal excursion which is frequently replaced by paradoxical movement in which the affected leaf moves in a cranial direction during inspiration.

During pregnancy, and in the presence of an abdominal tumour or a subphrenic abscess, the diaphragm is displaced upwards. Conversely, pneumothorax, especially of the tension type, may cause downward displacement and flattening out of the normal curved outline. For the better appreciation of disease in the vicinity of the diaphragm, examination should be made in at least two planes—frontal and lateral.

CONGENITAL DEFECTS OF THE DIAPHRAGM

Complete absence of the diaphragm has been recorded, and the literature contains other references to absence of a single leaf. There are other cases in which the serous coats of the diaphragm are normally developed but the muscle itself is absent, and under these circumstances the abdominal viscera are drawn up into the thorax, these serous coats forming the sac of a true complete diaphragmatic hernia. Congenital hernia may also result from defective fusion of the several elements which unite in embryonic life to form the diaphragm; in front, the sternal and costal elements fuse at the level of the 7th rib, while behind,

at the level of the 12th rib, is the junction between the costal and lumbar origins. A case has been recorded in which defective development of the septum transversum left a communication between the abdominal cavity and the pericardium through the central tendon of the diaphragm.

The condition known as *eventratio diaphragmatica* may be of congenital origin if the normal development of the phrenic nerve is disturbed. The muscle layer is replaced by fatty and fibrous tissue and the affected leaf rises into the thorax, followed by some of the abdominal contents. In rare instances this process may be confined to a circumscribed area, so that a localised invagination into the chest may result. The congenital form of eventratio is almost invariably on the left side.

WOUNDS OF THE DIAPHRAGM

Rupture of the diaphragm from indirect violence is more common on the left side because the liver serves to protect the right leaf from sudden stress. Rupture of the diaphragm occurs together with injury of the abdominal viscera in buffer accidents, and it may be associated with crushing injuries of the chest wall when the splintered ribs act as a direct traumatic agent. The condition has also been recorded after vomiting and child-birth when a diseased muscle has given way to the stress of a suddenly increased abdominal tension.

The following case history (Sauerbruch) illustrates rupture of the diaphragm in the absence of an external wound:

> A driver was struck in the upper abdomen by the shaft of a waggon. He was admitted to hospital in a moribund condition and at autopsy was found to have a gap in the central tendon of the diaphragm, through which part of the stomach had herniated. There was a hæmatoma of the anterior abdominal wall, but the skin was intact

Wounds of the diaphragm by direct violence are more frequent, being occasioned by gunshot or stab wounds. Almost invariably wounds of the thoracic or abdominal viscera are present. There is a series of 23 cases treated at the Sauerbruch Clinic, reported by Fick, and in only one instance was the lesion confined to the diaphragm; in 10 cases, wounds of both thoracic and abdominal viscera were found. The immediate danger is hæmorrhage from lung, liver or some other viscus; only rarely is a large vessel of the diaphragm such as the pericardiacophrenic involved. A more remote danger is infection from perforation of some hollow organ such as the stomach or colon. Still more remote is the danger of gangrene of the prolapsed viscera (figs. 2789 and 2790).

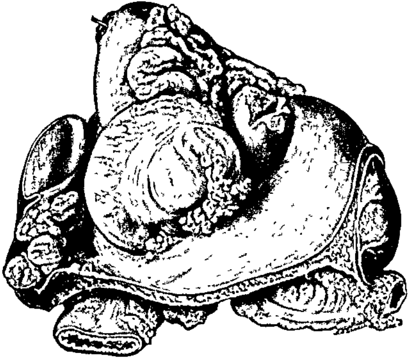

Fig. 2789.—Gunshot wound of the diaphragm (posterior view). The stomach, upper pole of the spleen and part of the transverse colon have passed through the rent in the diaphragm, and there is a perforation in the fundus of the stomach.
(*Museum, Royal College of Surgeons.*)

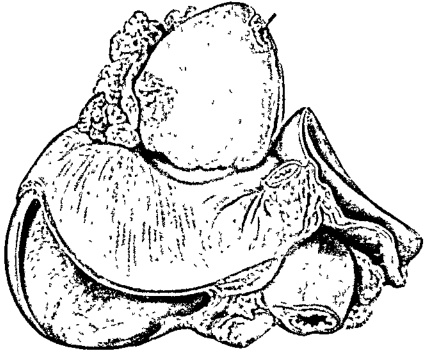

Fig. 2790.—Gunshot wound of the diaphragm. Anterior view of same specimen as shown in *Fig.* 2789.
(*Museum, Royal College of Surgeons.*)

The diagnosis of a wound of the diaphragm is not always easy. The appearance of omentum or some other abdominal organ in the chest wound is, of course, pathognomonic, and in other cases dyspnœa or pain referred to one or other shoulder may give assistance. In the case of rupture of the diaphragm without an external wound. the syndrome of tension pneumothorax is closely simulated. The sudden entrance of abdominal viscera into the chest causes dyspnœa and displacement of the heart, just as does the sudden entrance of air from a wounded lung or bronchus. The radiological appearances and an estimation of the intra-pleural pressure may enable a distinction to be made. The effects of shock and loss of blood commonly dominate the picture, and only after some restorative measures does a complete examination become possible.

The lesions usually associated with rupture of the diaphragm demand *surgical treatment*.

The lesion may be approached either through the abdomen or through the chest wall. An adequate exposure is essential, and to this end section of the costal cartilages after the manner of Marwedel (see Vol. I, page 509) assists in the exposure of the diaphragm from below. A small wound in the diaphragm will heal provided interposition of omentum or viscera does not occur. In a severely injured patient, once the visceral damage has been repaired it is unjustifiable to prolong the intervention in order to restore continuity of the diaphragm, unless the opening is so large as to threaten immediate prolapse of abdominal viscera. The abdominal route is to be preferred if there is evidence of perforation of stomach or intestine. Coincident injury of the lung would impel choice of the transpleural route, which has the same advantages as in operations for diaphragmatic hernia. Crushing of the phrenic nerve as it courses over the pericardium assists in subsequent manipulations. Organs such as the liver and spleen are readily accessible by enlarging the wound in the diaphragm (figs. 2791 and 2792).

The results of the surgical treatment of wounds of the diaphragm are naturally more favourable in the injuries suffered in civil life. The most remarkable series of war cases is reported by Gordon-Taylor. In all, 207 operations were carried out for combined abdomino-thoracic wounds with a 66 per cent recovery-rate. Gordon-Taylor's personal series was 75 cases with an immediate mortality of 16 per cent; he operated through the chest.

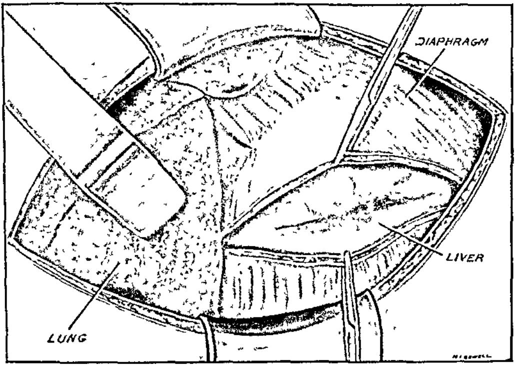

Fig. 2791.—Transdiaphragmatic laparotomy. (*After Jehn and Sauerbruch*)

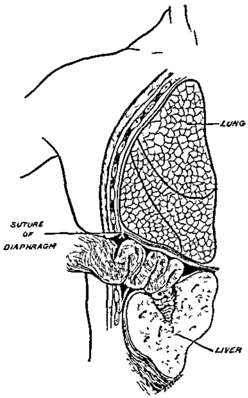

Fig. 2792.—Method of repairing a wound in the diaphragm accompanied by hepatic laceration.

(*After Jehn and Sauerbruch.*)

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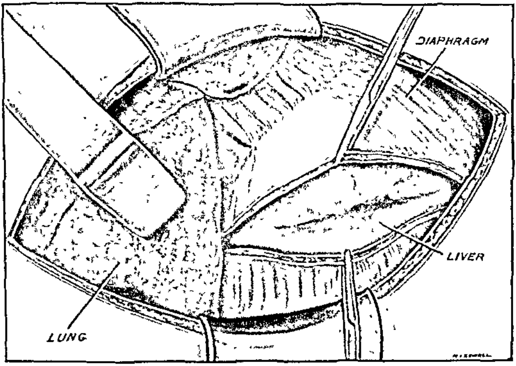

Fig. 2791.—TRANSDIAPHRAGMATIC LAPAROTOMY. (*After Jehn and Sauerbruch*.)

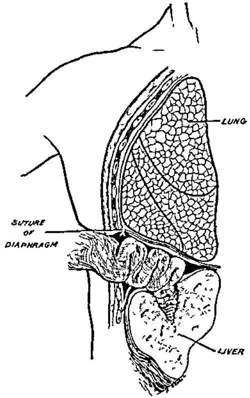

Fig. 2792.—METHOD OF REPAIRING A WOUND IN THE DIAPHRAGM ACCOMPANIED BY HEPATIC LACERATION. (*After Jehn and Sauerbruch*.)

DIAPHRAGMATIC HERNIA

A breach *in continuity of* the diaphragm is followed by an invasion of the thorax by abdominal viscera. Omentum, stomach and colon may enter the sac of such a hernia; small intestine, spleen, or even pancreas may be found. The mere presence of these organs in such an abnormal site is quite compatible with life and may even fail to produce discomfort, but, as in other types of hernia, disaster follows constriction of the neck of the sac or the formation of adhesions between the various contents. A classification of diaphragmatic hernia (after Eppinger) is given in the accompanying table, but the essential division is between hernia of traumatic origin and hernia presenting in patients who have never suffered local injury:

HERNIA DIAPHRAGMATICA

(1) *Hernia Vera.*

Hernia diaphragmatica vera congenita
Hernia diaphragmatica vera traumatica
Hernia foraminalis:

(*a*) parasternalis
(*b*) foraminis Bochdalecki
(*c*) para-œsophagea
(*d*) foraminis nervi sympathetici

(2) *Hernia Spuria.*

Hernia diaphragmatica spuria congenita
Hernia diaphragmatica spuria traumatica

(3) *Eventratio Diaphragmatica.*

(*a*) diffusa
(*b*) circumscripta

The site of the hernia of traumatic origin is obviously determined by the position of the original lesion and so obeys no special law. At the time of injury the pleural and peritoneal investing coats are usually involved, so that there is direct communication between abdomen and thorax. In some instances one serous coat, either pleura or peritoneum, may escape injury and so provide a serous covering for the herniated viscera.

The site of a hernia which arises in the absence of trauma is determined by the condition of the foramina, especially the œsophageal hiatus, and by the degree of fusion between the several components of

the diaphragm during embryonic life. In certain cases it is clear that the hernia is of true congenital origin, but in others it may be that herniation through an area of congenital weakness occurs as the result of stress. Congenital diaphragmatic hernia is almost invariably

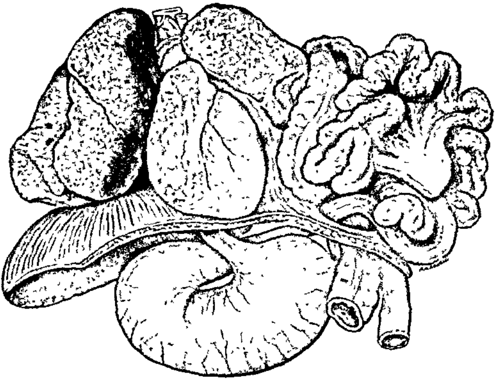

Fig. 2793 —DIAPHRAGMATIC HERNIA. THE COLON AND SMALL INTESTINE ARE PRESENT IN THE LEFT PLEURA. THE PATIENT HAD SUFFERED A GUNSHOT WOUND OF THE CHEST SOME FOUR YEARS PREVIOUSLY.
(*Museum, Royal College of Surgeons*).

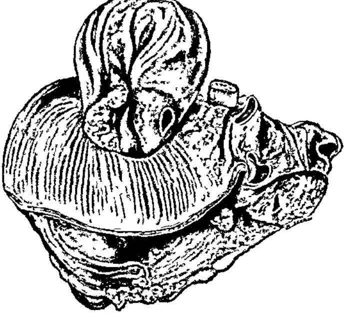

Fig 2794 —DIAPHRAGMATIC HERNIA. A PORTION OF THE STOMACH IS SEEN PROTRUDING INTO THE LEFT PLEURA. THE VISCUS WAS PERFORATED BY A GUNSHOT WOUND OF THE CHEST.
(*Museum, R C S*)

on the left side, and in one of the following regions: the œsophageal hiatus; very rarely, the foramen which serves for the passage of the greater or lesser splanchnic nerve; the interval between the lumbar and costal origins at the level of the 12th rib (foramen Bochdalecki); or the interval between the sternal and costal origins at the level of the 12th costal cartilage (foramen Morgagni). The aortic and caval foramina have never served as the site for a diaphragmatic hernia.

The clinical picture presented by the various types of diaphragmatic hernia depends on the important feature common to all—the presence of abdominal viscera in the chest. In many cases symptoms are few and only the accident of strangulation causes the patient to seek relief. Alternatively, a sense of discomfort in the chest, increased after food and

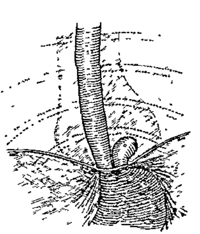

Fig. 2795.—Hiatus hernia.

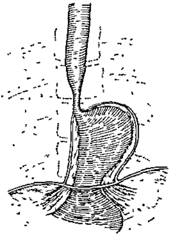

Fig. 2796.—Thoracic stomach.

(*By kind permission of Sir Thomas Dunhill and the "British Journal of Surgery."*)

accompanied by some degree of dyspnœa, leads to examination of the patient. Hæmatemesis, melæna, cardiac distress, pain in the epigastrium or pain referred to the left shoulder are among the symptoms described. A picture closely resembling that of peptic ulcer is often presented and such a lesion may actually occur in the displaced stomach or duodenum. It seems certain that vague symptoms may persist for years before their severity is such as to cause serious complaint.

The diagnosis of diaphragmatic hernia is reached without undue difficulty, especially if adequate radiology is available. The entrance of abdominal viscera into the thoracic cavity produces displacement of the heart to the right; gaseous distension of stomach or colon may enable characteristic signs to be elicited by percussion, and a scaphoid depression of the abdominal wall may also be present. In the event of incarceration or strangulation, the signs and symptoms of intestinal obstruction are added to the picture.

Hernia sternalis is remarkable in being the only type which is more common on the right side. Displacement of the heart to the left is a characteristic feature. The sac contains part of the stomach or a part of the transverse colon and it is rare for serious symptoms to arise.

Hernia foraminis Bochdalecki is one of the commonest types of congenital hernia which often proves fatal in early infancy. A sac is usually absent.

Hiatus hernia has assumed great clinical importance of recent years. Akerlund demonstrated in a large series of cases a peculiar invagination of part of the cardiac end of the stomach through the œsophageal hiatus. The invagination was only demonstrated when radiological examination was carried out after the ingestion of a radio-opaque meal with the patient in the Trendelenburg position. Patients in whom the syndrome could be detected were said to suffer from dysphagia as a cardinal symptom. Very shortly there appeared reports from other clinics of the association of cardio-vascular symptoms with hiatus hernia and the diagnosis came to be established in a surprisingly large series of cases. In 1932 Sauerbruch and Chaoul published a criticism of recent work on hiatus hernia in which they pointed out that the radiological appearances said to be characteristic of the condition could be demonstrated in normal individuals. They did not dispute the occasional occurrence of a true hiatus hernia, but they emphasised its rarity. A similar conclusion was reached by Schatzki, and Hurst has recorded in detail two cases in which the syndrome was associated with discomfort and dysphagia and both were relieved by conservative measures. He regards hiatus hernia as a rare clinical entity. Key has pointed out that the condition assumes real importance when viscera other than portion of the stomach enter the sac; he collected twenty-six examples from the literature and in six of these operation was carried out for strangulation. There is another very remarkable case described by Dunhill in which the entire stomach had herniated through the œsophageal hiatus so that the pylorus lay above the diaphragm; a successful radical operation was performed.

The radiological appearances of a diaphragmatic hernia are seen in the illustrations (figs. 2797 and 2798). Confusion has arisen between hernia, subphrenic abscess, pyo-pneumothorax and transposition of viscera, but complete radiological investigation should eliminate such sources of error. The greatest confusion has arisen in the case of hiatus hernia which has to be distinguished from an epiphrenal diverticulum of the œsophagus and from thoracic stomach.

Epiphrenal diverticulum is a rare lesion of the lower end of the

Fig. 2797.—Diaphragmatic hernia on the left side. (*By the courtesy of Sir Thomas Dunhill.*)

Fig. 2798.—Diaphragmatic hernia on the right side. Successful operation subsequently performed by right transpleural route. (*By the courtesy of Mr. G. A. Mason.*)

Fig. 2799.—Thoracic stomach. (*X-ray photograph by Dr. H. H. Worth. By kind permission.*)

œsophagus which lies completely above the diaphragm and is easily demonstrated by means of a radio-opaque emulsion with the patient in the *standing* position.

Thoracic stomach is a congenital abnormality in which the œsophagus terminates in the middle of the chest and the greater part of the stomach lies above the diaphragm (fig. 2799). Eventratio diaphragmatica is clearly shown in its complete form; in its more rare, circumscribed form, only operation will demonstrate that the remains of a muscular layer enter into the composition of the sac.

The Operative Treatment of Diaphragmatic Hernia.

For the purpose of diagnosis some division of the various types has been attempted, but from the point of view of operative relief these distinctions are not so important. The hernia must be exposed, its contents returned to their natural surroundings, and the breach repaired.

The transpleural approach enables the operation to be carried out on these lines. The abdominal route may occasionally be employed in approaching wounds of the diaphragm, but in the case of hernia it is not to be recommended. A hernia of long standing may be adherent to vital structures such as the heart or lung, and the separation of such adhesions except under direct vision is fraught with danger. Reduction of the contents of the sac, as in the case of other herniæ, is sometimes only possible after enlarging the hernial orifice and this, too, demands clear exposure. Any adhesions between the viscera still in the abdomen are readily accessible through an incision of proper length in the diaphragm. The abdominal approach has been recommended by some authorities, especially in the case of the hiatus hernia. It has been found possible to effect repair of the opening in this manner, but excision of the sac presents greater difficulty.

Strangulation forms an urgent indication for operative intervention. Increase of symptoms pointing to a more gradual process of incarceration would also constitute an indication, but in the absence of marked symptoms operation should be avoided. There are patients who exhibit marked emaciation as the result of a diaphragmatic hernia, so that the diagnosis of chronic peptic ulcer or carcinoma of the stomach is considered. In these cases the inclusion of stomach and intestine, often with the formation of secondary adhesions, has led to such disturbance of normal alimentary function as to justify, or indeed demand, operative relief.

Technique of the Radical Operation.

Transpleural Route (fig. 2800). Positive pressure anæsthesia is employed, and the patient is placed on the sound side. The thorax is opened by an incision in the 8th or 9th interspace, and after inspection of the hernia access is facilitated by the resection of segments of the adjoining ribs and by adequate retraction.

Separation of the sac from its surroundings is preceded by section or crushing of the phrenic stem just above its entrance into the diaphragm. Next follows incision of the diaphragm in the vicinity of the hernial opening and, once access to the peritoneal cavity has been

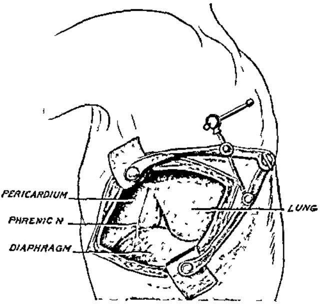

Fig 2800.—Left transpleural exposure of the diaphragm.
("Brit. Journ. Surg.")

gained, reposition of the contained viscera is usually easy. In case of need the incision is extended into the hernial orifice until the neck of the sac is exposed.

Repair of the defect is the next stage, and this may be attended with difficulty if the muscle has undergone fibrosis and atrophic changes. Suture of the liver or even of the stomach into the margin of the opening may be the only means of closure. In other instances, after partial suture of the defect a graft from the fascia lata must be employed. Faced with the problem of repairing an especially large breach in the muscle, its lateral portion may be mobilised by resection of the lower ribs as in the operation of thoracoplasty. In this way suture of the defect may be carried out without undue tension. Finally, after expansion of the lung the chest wall is closed in the usual way.

Abdominal Route. The method of exposure of the œsophageal

hiatus is described on page 5081. Retraction of the left lobe of the liver and division of the left suspensory ligament is essential.

After reduction of the contents, the opening in the diaphragm is closed by interrupted sutures.

Strangulated Diaphragmatic Hernia. The accident of strangulation is determined by the entry of intestine into the sac. Strangulation of the stomach alone has not been recorded. The onset is usually sudden, and the symptoms of acute intestinal obstruction are displayed. Rarely, angulation of the junction between stomach and œsophagus may prevent vomiting. Frequently a displaced portion of colon is the actual site of obstruction, and it is also possible for strangulation of a loop of jejunum to produce the picture of high intestinal obstruction. Abdominal distension is present in all cases unless the greater portion of the gastro-intestinal tract is contained in the thorax.

Diagnosis is assisted by a previous history of local injury or of such symptoms as oppression after meals, singultus, precordial or epigastric discomfort, pain in the left shoulder, and attacks of dyspnœa.

Treatment is operative, although intervention in the presence of strangulation carries a high mortality. Approach should be from above as in the deliberate operation for radical cure. The passage of a stomach tube is a useful preliminary to operation. Should the diagnosis be established only after laparotomy has been carried out. recourse to the thoracic route is still to be recommended. Some surgeons have found it possible to carry out a short-circuit operation to relieve the obstruction, reserving cure of the hernia till a later date. In desperate cases when radical operation cannot be attempted, the palliative measure of phrenicectomy may be employed.

Results of Operative Treatment.

Although the necessity for intervention in any case of diaphragmatic hernia manifesting symptoms requires no statistical justification, some recent figures are of interest. Excluding hiatus hernia, Hedblom has reported on 22 operations, with 2 deaths and satisfactory results in the remaining cases. He found that there were recent records of 9 infants under 1 year who had undergone a radical intervention for diaphragmatic hernia—of these 3 died and amongst the survivors was 1 infant only 40 hours old. Another survivor of 3 months required multiple rib resection before the operation could be completed. Truesdale has also reported a series of successful cases of the transpleural route. Sauerbruch, the main protagonist of the transpleural route, reported one series of 83 operations to the French Surgical Congress. There were

5 deaths and of these 3 were from operation undertaken for strangulation. Harrington has reported on 105 operations, of which 76 were undertaken for hiatus hernia. He advocates the abdominal route in all cases.

EVENTRATIO DIAPHRAGMATICA

The syndrome may be of congenital origin or may result from invasion of the phrenic nerve by disease of the surrounding parts. Metastatic new growth in the mediastinum may be instanced. Eventratio diaphragmatica also follows the operation of phrenic evulsion.

In eventratio diaphragmatica there is paralysis together with muscular atrophy, so that the affected leaf rises up into the thorax and with it the underlying abdominal viscera. The condition is more common on the left side, and it is rare for any untoward symptoms to arise. Incarceration of the viscera is not possible because there is nothing to correspond to the neck of a hernial sac. In rare instances symptoms of dysphagia have arisen, the result of an angulation of the œsophagus which has been caused by the upward displacement of the stomach. In such cases a plication operation on the relaxed diaphragm may be carried out.

The diagnosis is usually established by simple radiology. The affected leaf exhibits paradoxical movement. that is to say, expiration is attended by descent. Hitzenberger has recommended the application of pneumoperitoneum in doubtful cases, but this measure is not entirely free from risk. Eventratio of the acquired type may be localised. and thus a circumscribed invagination of the diaphragm may come about. In theory this condition might provoke symptoms, but its chief importance lies in the fact that more serious lesions, such as an œsophageal diverticulum, may be stimulated.

NEW GROWTHS OF THE DIAPHRAGM

A primary neoplasm of the diaphragm is one of the rarest tumours. Kirschbaum has reported the autopsy findings in 2 cases of sarcoma who died with multiple metastases and he states that only 6 other cases have been described.

Secondary tumours are more common, and as long ago as 1924 Hesse, in reporting a personal case, could find records of 17 other cases in which radical operation had been performed for a tumour of the chest wall invading the diaphragm.

The diagnosis of tumours of the diaphragm can only be established by radiology, and there exists only one account of radical operation for such a tumour—a case reported by Sauerbruch.

Technique of Resection of the Diaphragm.

Approach must be from above, by an intercostal incision which permits adequate exposure of the muscle and enables the stem of the phrenic nerve to be crushed or divided above its point of entrance into the diaphragm. This is a most important preliminary to resection.

When the tumour involves chest wall and diaphragm, resection of the affected ribs together with the intercostal muscles is first carried out; phrenicectomy is the next step, and finally, using the resected portion of the tumour as a handle, an appropriate resection of the diaphragm is performed. Care must be taken to avoid injury to the intestines or stomach, should these viscera be adherent to the tumour. The introduction of the finger into the peritoneal cavity through a small preliminary incision in the diaphragm is recommended.

In most cases there is no difficulty in closing the wound in the diaphragm, but, should this difficulty arise, suture of the remaining portion of the muscle to the margin of the chest wound may serve to separate pleural and peritoneal cavities. A graft of fascia lata may also be of service, or the defect may be closed by suture of the upper surface of the liver into the gap.

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PART XXXII

MANDIBLE

by

CECIL P. G. WAKELEY

SECTION 1

INJURIES (EXCLUDING FRACTURE) AND DISEASES OF THE MANDIBLE

SECTION 2

ODONTOMES

SECTION 1

INJURIES (EXCLUDING FRACTURE) AND DISEASES OF THE MANDIBLE

DISEASES OF THE TEMPORO-MANDIBULAR JOINT

THE temporo-mandibular joint is a diarthrosis and has two synovial cavities which are separated by a firm interarticular disc of fibro-cartilage. This disc is an oval plate which is interposed between the articular cartilage of the glenoid fossa of the temporal bone and that of the condyle of the mandible. It is thinnest posteriorly and thickest at the centre; this is somewhat at variance with anatomical teaching, but has been proved by surgeons who have had to remove this cartilage on many occasions. It is never perforated except by disease. The superior surface of the cartilage is concavo-convex from before backwards, in adaptation to the convexity of the eminentia articularis and the concavity of the glenoid fossa. Its inferior surface is concave and fits upon the condyle of the lower jaw (see fig. 2801).

DISLOCATION OF THE MANDIBLE

The temporo-mandibular joint is quite a stable structure and is well protected, so that dislocation is not common. Forward dislocation may result from muscular action, or from trauma as in the case of a blow received on the point of the chin when the mouth is open. It may follow the forcible extraction of one of the lower molar teeth or the use of an elevator in removing a stump from the posterior part of the alveolus. Dislocation may occur during a fit of laughing, gaping, or violent yawning, or when an attempt is made to take too large a bite. In other cases dislocation has resulted from the excessive use of a dental prop or a gag, or from forcing too large a body into the mouth during anæsthesia.

The mechanism of the dislocation is quite simple—the condyle of the mandible slips over the eminentia articularis into the zygomatic fossa. The interarticular fibro-cartilage follows the condyle, as the external pterygoid muscle is attached to both. The dislocation is usually bilateral but may be unilateral, depending on the exciting cause (see fig. 2802). The mouth is held open and the interval between the teeth is about one inch. The lower jaw is fixed by the contraction of the muscles surrounding the joint, and it is this muscle spasm which causes the pain in this dislocation. Speech and deglutition are impaired, and saliva continuously dribbles over the lip. On examination a hollow can be palpated immediately in front of the tragus where the condyle is normally situated, and in front of this the condyle itself can be felt.

On passing a finger into the mouth, the coronoid process can be found in an abnormal position just below the zygoma.

The treatment consists in reduction of the dislocation at the earliest possible moment. As a rule, reduction is quite easy, as all that is necessary is to depress the condyle of the jaw below the level of the eminentia articularis, when the contraction of the posterior fibres of the temporal muscles, the masseter, and the internal pterygoid muscles quickly pulls it back into the glenoid cavity. It is necessary for the surgeon to protect his thumbs with a towel, as during reduction the contraction of the powerful muscles of mastication may result in a

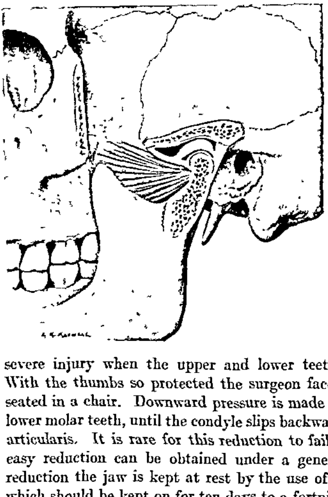

Fig 2801.—Drawing showing a section of the temporo-mandibular joint. The position of the intra-articular disc can readily be seen.

severe injury when the upper and lower teeth come into contact. With the thumbs so protected the surgeon faces the patient, who is seated in a chair. Downward pressure is made by the thumbs on the lower molar teeth, until the condyle slips backwards over the eminentia articularis. It is rare for this reduction to fail, but should it do so, easy reduction can be obtained under a general anæsthetic. After reduction the jaw is kept at rest by the use of a four-tailed bandage which should be kept on for ten days to a fortnight.

As a rule, dislocation at this joint does not weaken the articular and peri-articular structures, so that recurrent dislocations are rarely seen. However, exceptional cases do occur when the joint is quite lax owing to repeated dislocation having taken place, the patients

often having surprisingly little pain or discomfort and being able to reduce the luxation quite easily themselves.

Unreduced dislocations may be seen occasionally owing to the fact that the condition has not been diagnosed. A false joint may form and, gradually, the patient manages to eat, swallow and talk, but the dislocation still remains very obvious. If the dislocation has been present for some months, reduction may be impossible owing to the fibrosis of some of the masticatory muscles. In such cases it is advisable to excise the condyle to allow of better movement of the jaw and to restore normal mastication.

Dislocation of the jaw backwards is always associated with fracture of the tympanic plate and separation of the cartilage of the auricle,

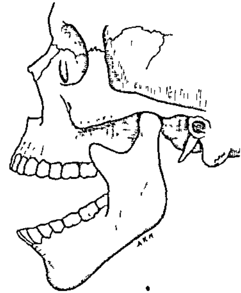

Fig. 2802.—Dislocation of the mandible.

while dislocation upwards results in a fracture of the middle fossa of the skull; both these fracture-dislocations are uncommon and are usually fatal accidents.

DISPLACEMENT OF THE MANDIBULAR CARTILAGE

This is a rare accident and is probably due to the shape and attachments of this meniscus. The temporo-mandibular joint is divided by the fibro-cartilaginous disc into two cavities, each provided with a distinct synovial membrane. The circumference of the disc is adherent to the capsular ligament, and, anteriorly, affords partial insertion to the external pterygoid muscle. It is owing to the fact that there are two definite cavities in this joint that movements of two different kinds can take place. These movements are somewhat complex. Gliding movements, whereby the interarticular disc and the condyle

move together as one on the temporal bone, take place in the upper synovial cavity. Further, a rotation between the disc and the condyle occurs in the lower synovial cavity. Probably these two movements rarely take place independently of one another.

The somewhat frequent displacement of the medial meniscus of the knee joint is due to the fact that the cartilage is placed at the periphery of a very shallow concavity, and also to the fact that the internal lateral ligament of the knee joint is adherent to it. The latter fact is important since, whenever this ligament is put on the stretch, it tends to pull the meniscus beyond the limits of the joint. Displacement of the internal meniscus of the knee joint is the result of some sudden movement of the joint; similarly, displacement of the mandibular meniscus is due to some sudden or irregular contraction of the external pterygoid muscle. Unlike the medial meniscus of the knee joint, which may be torn or ruptured, the mandibular cartilage always remains intact. Displacement of the cartilage may be caused by a violent cough, sneeze or yawn, the external pterygoid muscle contracting during the rapid closing of the mouth and drawing the cartilaginous disc obliquely forwards and inwards. Occasionally, displacement may result from a blow on the jaw when the mouth is open, the trauma not being of sufficient force to cause dislocation of the condyle over the eminentia articularis of the temporal bone. Again, displacement occurred in one of my patients as the result of extraction of one of the lower molar teeth.

The posterior thinned-out part of the meniscus becomes detached from the capsule, and this permits it to be drawn forwards and inwards by the external pterygoid muscle, and as the mouth closes by elevation of the jaw, the disc of cartilage becomes severely crushed between the condyle and the temporal bone (fig. 2803).

The symptoms caused by such a displacement are very characteristic. The patient experiences sudden acute pain in the joint which may be referred to the pinna or the skin above the pinna. This referred pain is due to the fact that the auriculo-temporal nerve not only supplies the joint, but also gives off sensory branches which supply the upper part of the pinna and the skin above it. All attempts to close the mouth are painful and the patient will sometimes volunteer the remark: "There is something sticking in front of my jaw which prevents me from shutting my mouth." Excessive salivation is often a marked feature, but in old-standing cases or in those in which the meniscus is very mobile owing to repeated displacement, it is often so slight as not to cause the patient any annoyance. Mastication is attended with

considerable difficulty, as even slight chewing causes acute pain. This, however, becomes less marked in a day or so, probably due to the fact that a definite synovitis is set up when the primary displacement takes place. This synovitis causes the capsule of the joint to become very tense, and this in itself will account for the pain felt when movement occurs in the joint. When the synovitis becomes chronic, the pain is much less marked and greater mobility of the meniscus is possible. Quite often, the patient suffers from continually recurring displacement which cannot be regarded as acutely painful but is very

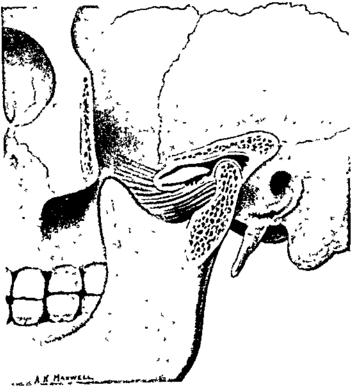

Fig. 2503.—Displacement of the Mandibular Cartilage. The posterior part is detached and the whole disc is drawn forwards.

distressing, since the meniscus slips in and out of position and causes a definite audible snap. In a few cases I have seen, this snap has been a source of great annoyance to the patient, especially at meal times, making him afraid to eat in public for fear of attracting attention.

As regards *treatment*, reduction is much more likely to succeed and be permanent if it is performed on the occasion when the meniscus is first displaced. In old-standing cases the effect of the reduction is temporary only. The best method of reduction is to maintain continual pressure behind the condyle of the jaw while the mouth is open. By this means the convex upper part of the condyle will be insinuated into the concave lower surface of the meniscus. After a few minutes of this continued pressure the mouth is closed by slowly elevating the jaw.

Sometimes the meniscus slips back with an audible click, while in others nothing is noticed at all, but the patient states that the obstruction in the joint has disappeared. Several attempts are often necessary before reduction is complete.

In cases where displacement is more or less continuous, the same changes take place in this joint as occur in the larger joints, e.g. the knee, when there is recurrent displacement of the medial meniscus. The peri-articular tissues, capsule, ligaments and muscles become repeatedly stretched and eventually relaxed ; this allows the meniscus to be displaced whenever the mouth is widely opened. In these chronic cases no treatment, with the exception of excision, is of any avail. Fortunately, most of these patients are quite content to put up with the slight pain and the inconvenience caused by the repeated "snapping" of the meniscus. Occasionally, however, one meets with a patient who implores the surgeon to give relief from the chronic pain and the continual "snapping" which is described as unbearable. One of my patients was actually contemplating suicide unless relief from the noise could be obtained. She explained that she was forced to take her meals by herself as her husband objected to "the noise she made when she was eating."

The following case gives a good clinical description of the condition, and of the type of operation advised :

Mrs. A., aged 31, came under observation in 1922, complaining of pain and a loud clicking noise in the right temporo-mandibular joint. The pain was first noticed two years previously ; it came on suddenly after a violent fit of coughing, and for a week at least the patient was unable to close her mouth properly. As the pain became less marked she felt as if some foreign body was in the joint, and whenever she opened her mouth at all widely she heard a definite click. The click was then noticed at meal times and became more audible, not only to the patient but also to her husband. When she came up to hospital she was in a very depressed condition, had lost two stone in weight during the previous year, and begged for relief from the constant clicking noise which she said was driving her mad. Local treatment, in the form of diathermy to the side of the face over the joint, was given for ten days, but without relief.

Operation was performed in June 1922, and the joint was explored through a T-shaped incision The capsule was opened and the cartilage was found to be extremely loose and attached in front only, having no connection whatever behind. The cartilage could be moved in any direction, even when the jaw was depressed as far as possible. Notwithstanding the two years' history, there was no sign of osteo-arthritis in the joint. The cartilage was drawn out of the joint and, its anterior attachment to the capsule and external pterygoid muscle having been severed, it was removed. The opening in the capsule was closed by three interrupted catgut sutures. The skin was approximated by three silkworm-gut sutures.

For the first 12 hours after the operation the mouth was kept closed by means

of a four-tailed bandage. After this an elastic strap was applied which allowed the mouth to be opened slightly. At the end of a week when the stitches were removed a small collodion dressing was applied and no bandage. The patient had no pain after the operation, even during mastication, and she was discharged in nine days. When seen again three months later, she was very pleased with her condition. She had experienced no pain whatsoever. The scar was only very slightly visible, and was easily covered by her hair. Movement of the jaw was normal.

SYNOVITIS AND ARTHRITIS OF THE TEMPORO-MANDIBULAR JOINT

Acute Synovitis. This is uncommon, but may be seen during an attack of acute rheumatism. There is some swelling of the articular and peri-articular structures, due to synovial effusion. Movements of the joint are painful and the patient is often afraid to speak or open the mouth. In most cases complete resolution takes place, but sometimes intra-articular adhesions form which eventually lead to impairment of movement.

Serum synovitis occasionally occurs in this joint, but leaves no aftermath.

Chronic Synovitis. This is a rare condition, but may be seen in cases of recurrent subluxation of the joint.

Acute Arthritis of the joint may be pyæmic in origin when it is a sequela of one of the exanthemata, or it may be secondary to gonorrhœa, acute parotitis, or acute otitis media. Post-scarlatinal otitis media is quite likely to be the cause of direct extension of inflammation through the tympanic plate into the joint. In children it may be difficult to diagnose the condition when an acute otitis is present, and an abscess formation, which rapidly points and bursts externally, may be the first indication that the joint is infected. It is important that such an abscess should be incised and drained as soon as it is diagnosed. Acute arthritis is invariably followed by ankylosis, which requires excision of the condyle at a later date when all signs of inflammation have subsided.

Chronic Arthritis. Osteo-arthritis is by no means rare in this joint, although it is quite often overlooked as a cause of pain in the joint. With modern methods of radiology the condition can be seen quite easily in a skiagram; it may be symmetrical, and is characterised by considerable enlargement of the condyle of the jaw which causes it to bulge laterally so that it can be felt in front of the tragus of the ear. Movements of the joint are painful and limited, and crepitus can nearly always be elicited. If the condition is bilateral, the lower jaw appears to be pushed forward, rendering the chin quite prominent; if, however, it is unilateral, the jaw becomes deflected to the sound side. Loose bodies may form in some cases and

may cause "locking" of the joint, while in others there is extensive lipping of the periphery of the condylar cartilage, proliferation of the synovial villi, and "lipoma arborescens" may be in evidence. As the disease progresses the interarticular cartilage may disappear completely, and the glenoid cavity, as it enlarges, may assume a flattened outline so that there may even be a partial dislocation. If pain and limitation of movement are complained of, the only satisfactory treatment is excision of the condyle, as all other forms of treatment are useless and a waste of time.

The operation of *excision of the condyle of the jaw* is carried out through a curvilinear incision, commencing over the middle of the zygoma, and passing downwards in front of the tragus. In this operation the surgeon is working in a somewhat cramped space with the zygoma above, the facial nerve below, the parotid gland in front, and the external ear behind. After the skin and subcutaneous tissues have been incised, the small flap is turned upwards. A transverse incision is now made at the posterior end of the zygoma, opening up the capsule of the joint and the synovial membrane. The neck of the mandible is exposed, and a fine Gigli saw is passed round this with a small aneurysm needle. The neck of the bone is cut through with this saw and the condyle removed. Sometimes the neck of bone may be divided with a small pair of cutting pliers. Any bleeding from the cut surface of the bone can be controlled by the firm application of some bone wax to the raw area. A small piece of celluloid can be placed over the cut surface of the bone and retained with a stitch. This prevents any chance of ankylosis of the joint. A piece of fascia may perform the same purpose, while some surgeons advocate the use of a portion of the tunica vaginalis testis. The wound is closed with two or three interrupted sutures, no drainage being employed. The patient is encouraged to move the joint at an early date. The results of such an operation as this are really gratifying, and patients are quite pleased.

Tuberculous Arthritis. It is often difficult to be certain whether tuberculous disease in this joint has arisen in the bone or in the synovial membrane. The affection itself is rare and is only seen when the disease is fairly well advanced. It runs the usual course of any tuberculous joint affection and ends in caries of the condyle. Secondary infection may occur, leading to ankylosis. The condition is very chronic and has been mistaken for osteo-arthritis on more than one occasion, the true diagnosis only being made when excision of the condyle was performed and the bone subjected to microscopical examination. Excision of the condyle and thorough cleansing of the

cavity of the joint, followed by the application of B.I.P.P., is the treatment for this condition.

Neuropathic arthritis of this joint is a very rare entity: a *hypertrophic Charcot's arthritis* has been reported in the literature.

FIXITY OF THE JAW (TRISMUS)

Immobility or closure of the jaw may be the result of a great variety of conditions. The following are the most important:

(1) *Fibrous or osseous ankylosis may result from any acute* suppurative condition.

(2) *Old-standing dislocations*, where a *false* joint has formed in front of the glenoid cavity; in chronic cases of osteo-arthritis where the amount of osteo-arthritic outgrowth is excessive; in cases of fracture of the neck of the mandible with excessive callus formation; and rarely in cases of cyst, or tumour formation in the head or neck of the mandible.

(3) Cicatricial contraction of the surrounding soft structures, as from burns and scalds, lupus, cancrum oris, and scars resulting from operations or the application of radium in the pterygoid region. Gummatous infiltration of the masseter muscle leading to fibrosis occasionally occurs as a result of syphilis. Very rarely, myositis ossificans has been the cause.

(4) Spasm of the muscles of the jaw due to reflex irritation or *impacted third molar tooth. Occasionally, the spasms may be hysterical* in nature, and are one of the early signs of tetanus.

(5) The pain and swelling of local inflammatory *conditions often* render opening of the mouth impossible; among the commoner of these may be mentioned mumps, parotid abscess, lymphadenitis, acute tonsillitis, and acute alveolar periostitis. Any malignant growth of the face or cheek may seriously impair the mobility of the jaw. Likewise extensive actinomycosis of the skin covering the jaw, and acute necrosis of the mandible with sinus formation may lead to extensive fibrosis which will eventually cause fixity of the jaw.

The treatment of the different varieties of fixation of this joint will of necessity vary according to the causative conditions.

Fibrous ankylosis can be dealt with by excision of the condyle of the jaw already described.

Bony ankylosis (see fig. 2804) often presents a difficult problem owing to the fact that the surgeon is working in a limited space, and any attempt to remove the neck or head of the condyle by means of a chisel or osteotome may result in a fracture into the middle ear or injury to

the facial nerve (fig. 2805). A fine pair of nibbling forceps may be used, and the bone in the region of the neck of the mandible be carefully removed, piece by piece, until the bone is completely divided. It is important to remove a considerable portion of bone so as to leave quite ½-inch between the two surfaces. A piece of fascia lata, celluloid, or muscle graft should be inserted between the bony surfaces so as to ensure a false joint and prevent any bony union (fig. 2806). It is often possible to turn in a flap of the temporal muscle without extending the incision and without interfering in any way with the action of the

Fig. 2804.—SPECIMEN OF BONY ANKYLOSIS OF THE JAW OF MANY YEARS' STANDING. (*Museum, R.C.S.*)

muscle itself (fig. 2807). In bilateral cases, after the stitches are removed, it may be necessary to move the jaw repeatedly under gas anæsthesia to ensure free movement. The end-results in these cases depend to a large extent on the patients themselves; the persevering ones get excellent results, while the nervous patients who will not try to move their jaws often complain that the operation has been a failure and that they are little benefited by the surgical intervention. The surgeon should try to assess every patient before undertaking the operation, when he will be able to gauge the probable reaction in each case. Some patients should never be operated upon, as failure is assured by their behaviour prior to operation.

The most difficult cases to relieve or cure are those in which there is

much cicatricial contraction round about the joint. Division or excision of the adhesions is useless, as, during healing, fresh adhesions form and the condition is unrelieved. In these cases, therefore, *Esmarch's operation* often gives good results. This operation consists in the

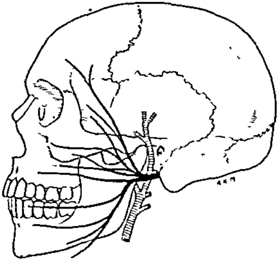

Fig 2805.—Diagram showing the relation of the facial nerve and the superficial temporal artery to the temporo-mandibular joint.

removal of a wedge of bone, with its apex towards the alveolar border, from the neighbourhood of the angle of the mandible (see fig. 2808). A portion of the detached masseter muscle is turned in between the two

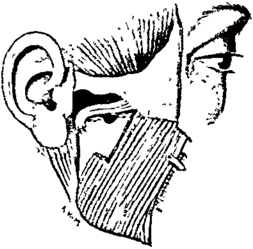

Fig 2806—Drawing showing how a strip of the masseter muscle may be used to ensure a false joint after excision of the condyle.

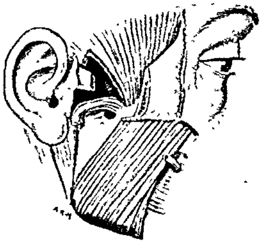

Fig 2807—Drawing showing how a strip of temporal muscle may be used to prevent bony union after excision of the condyle.

bony surfaces so that an artificial joint is formed. The incision should be made below and behind the angle of the jaw; this gives good exposure and allows the muscles to be separated from the outer and inner surfaces of the mandible. The bone can most conveniently be divided by the use of a Gigli saw. An alternative method is to remove

the vertical ramus of the jaw down to the level of the alveolus, but this method does not give so satisfactory a result as Esmarch's operation.

THE MANDIBLE

The mandible may be considered as a mixed bone because it is formed chiefly from membrane, but also from cartilage. It is ossified in connection with Meckel's cartilage and its fibrous investment. Each half of the bone has one centre which appears about the sixth week of intra-uterine life, being only preceded by the

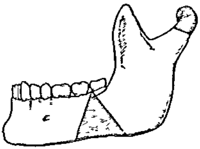

Fig. 2808.—Diagram showing the extent of bone removed in excision of the condyle and in Esmarch's operation.

primary centres of the clavicle. At birth the mandible consists of two halves, connected at the symphysis menti by fibrous tissue. The rami are short, so that each condyle is nearly on a level with the upper border of the symphysis (fig. 2809). In the course of the first year, osseous union takes place. As adult life is reached, the body of the mandible increases in depth, the rami lengthen and the angle decreases, while the mental foramen gradually assumes a position midway between

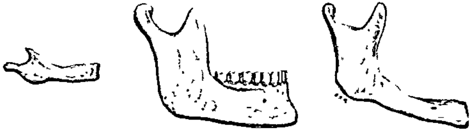

Fig. 2809.—Drawings showing the mandible at birth, at the age of forty, and at the age of eighty.

the superior and inferior borders. In old age, if the bone becomes edentulous, the whole of the alveolar border undergoes absorption, causing the body to become shallower. The rami drop backwards and each angle becomes increased to about 140 degrees. The mental foramen lies near or on the superior border, and the mental nerve may be irritated by the pressure of a denture.

INFECTIONS OF THE MANDIBLE

Septic infections of the mandible are quite common, and it is curious that they are not more common considering the very septic state in which the mouth is often found to be.

Osteomyelitis of the Mandible. Two distinct varieties may be recognised:

(1) Extensive acute involvement which simulates acute osteomyelitis of the long bones.

(2) Localised necrosis, due to local infection.

The *acute form* is very severe and is often fatal, but is fortunately rarely seen. The infection may be blood-borne or it may reach the bone from an adjacent infection in the teeth. As the lower jaw obtains its blood supply internally from the inferior dental artery, and externally from vessels supplying the periosteum, it can be imagined that various forms of the disease exist according to the source of the infection. The whole of the narrow cavity is supplied by the inferior dental artery which is enclosed in a dense canal, and if this artery is occluded by septic thrombosis there is destruction of a large part of the lower jaw. As a rule, the whole of the alveolar process, carrying with it the teeth, may necrose and become separated. Sometimes, a week or so after one side of the jaw becomes infected, the other side follows suit. There is a general constitutional reaction with high temperature, and at times rigors; the disease, if not fatal, follows the course of osteomyelitis of the long bones (see also Vol. II, page 3398).

In those cases where the disease is caused by extension of infection from the mouth, either from an infected tooth or from an injury, there may be a much more severe reaction owing to the fact that the infection is not due solely to the staphylococcus pyogenes aureus, but to a mixed infection in which a variety of organisms take part. In such cases extensive suppuration of the soft tissues of the neck may supervene, and there may be extension down the fascial planes of the neck into the mediastinum, resulting in a fatal mediastinitis.

With regard to *treatment*, this should be conservative on the whole. It may be necessary to incise the periosteum and drill the bone. Owing to the density of the osseous tissue of the lower jaw, it takes a long while for the necrotic bone to become extruded, much longer indeed than in the long bones. It may take several months, or even years, before all the sequestra finally become separated. The sequestra can be readily demonstrated by the use of X-rays, and, in removal, the surgeon should be careful not to fracture the jaw, as this can quite easily be done owing to the weakness of the surrounding involucrum.

Local Necrosis. This condition is quite common and is usually the result of infection from the teeth. The third molars appear to be the chief offenders, no doubt because they are most commonly misplaced and unerupted (see page 5180). Trismus is often a sign which requires to be fully interpreted, and here a skiagram will often clinch the diagnosis. The treatment should be carried out essentially by a dental surgeon.

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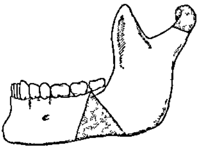

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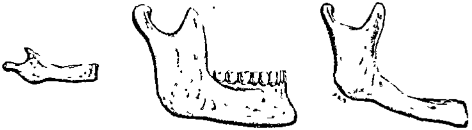

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drugs, especially if there is some oral sepsis present at the same time. The drugs which may cause necrosis are mercury, arsenic and antimony. Some patients are very susceptible to these drugs, and even the local use of arsenic in the preparation for filling a cavity in a tooth may lead to quite extensive destruction of portions of the jaw.

In cases of syphilis where there is extensive dental caries, the use of mercury and arsenic in the treatment of the disease must be carefully watched, as extensive necrosis or complete destruction of the

Fig. 2810.—Sequestrum removed from the mandible of a girl, aged thirteen, suffering from scarlet fever. (*Museum, R.C.S.*)

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Necrosis may be seen at times during the course of one of the exanthemata, especially in young children, when it may be a fatal

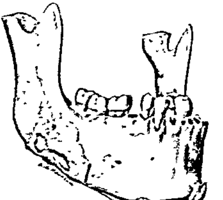

Fig. 2811.—Specimen of mandible showing phosphorus necrosis, from a man aged thirty-five who had been engaged in lucifer match making for twenty-three years. (*Museum, R.C.S.*)

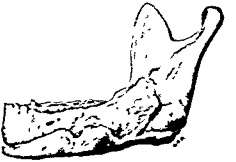

Fig. 2812.—Mandible from patient who died of phosphorus poisoning in 1862. (*Museum, R.C.S.*)

condition. Measles, scarlet fever, typhoid, chicken-pox and small-pox have all been known to be the causative agent in necrosis of the jaw (fig. 2810). In these cases an attitude of conservatism should always be adopted.

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and it was quite a common observation that both were affected at one and the same time. The fumes given off from the yellow phosphorus gain access to the jaw, generally through carious teeth, and set up an inflammatory reaction. Salivation and swelling of the gums and bone take place, and this is followed in quick succession by necrosis of the bone. The teeth become loosened, and finally drop out, and there is an exudation of pus from the empty sockets. The patient's health deteriorates rapidly owing to septic absorption, anæmia, and exhaustion due to anorexia; death may even take place from these complications. Sequestra, both large and small, are gradually formed, but take a long time to become sufficiently loose to be exfoliated. However, when a sequestrum separates or is removed, it is found to be of a curious yet characteristic appearance; it is bossy and porous, and may be likened to coarse pumice-stone. As a rule, a considerable involucrum forms and the lower jaw may be reconstituted again after separation of all the sequestra. Even after the separation of what appears to be the whole of the lower jaw in the form of a sequestrum, the jaw is remarkably re-formed and a denture can be worn at a later date.

Treatment should be conservative, with the removal of loose sequestra where necessary, the great essential being to build up the general health of the patient.

Radium Necrosis. This is a form of necrosis which has appeared with the advent of radium treatment for cases of carcinoma of the tongue. It is probably the most chronic and most painful form of necrosis which affects the lower jaw. It is preventable to a large extent, for the radium should be protected in a lead screen. Cases do arise, however, where every precaution has been taken and the necrosis, which is heralded by a chronic burning pain often for a month or more, becomes manifest by radiography before any clinical signs are forthcoming. Months pass before any clinical evidence of necrosis is to be seen, and sequestra slowly form and take a very long time to separate. Two or three years is often the actual time period for the separation of minute sequestra. In this condition again, conservatism is the treatment, any active interference causing a mixed infection and an osteomyelitis of the mandible (see also page 5132).

Actinomycosis of the Mandible. The lower jaw is quite commonly infected with the ray fungus, the infection commencing in a carious tooth or in an abrasion of the mucous membrane by a denture or a hard particle of food. There is some swelling of the bone which eventually leads to necrosis (see figs. 2813 and 2814). Multiple abscesses occur, which in turn form sinuses, and these discharge a sticky exudate

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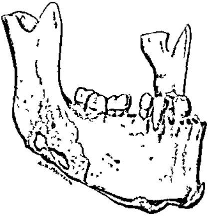

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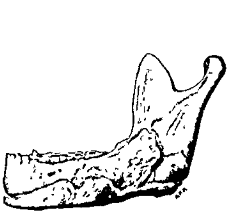

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containing the well-known "granules." Excessive fibrosis takes place about the sinuses, and the tissues appear to be markedly indurated. If the disease is not treated, slow extension takes place into the muscles in the neighbourhood, and the jaw may become fixed, causing difficulty in swallowing and breathing. The veins may be compressed, or, occasionally, erosion takes place with generalised metastatic deposits of the disease which kill the patient.

The *prognosis* is far from hopeless, and is quite good if the condition is still localised to the lower jaw.

Treatment must be local and general. *Excision of all necrotic tissue is essential*, and the area should be packed with gauze soaked in

Fig 2813.—Case of extensive actinomycosis of the jaw.

Fig. 2814.—Skiagram of patient with extensive necrosis of the mandible due to actinomycosis.

tincture of iodine. These packs should be changed daily. Indurated masses and sinuses should be incised and packed with iodine gauze.

The general treatment consists in giving large doses of potassium iodide up to 1000 grs. per diem. If the patient develops signs of iodism the dose should be doubled, not halved. The treatment should extend over six weeks or two months.

Vaccine treatment may be tried as an adjuvant method of treatment, but is not so satisfactory as intensive potassium iodide treatment.

During the treatment it is essential that the general health of the patient should be maintained by the use of a suitable nourishing diet and a tonic if necessary.

TUMOURS OF THE MANDIBLE

Innocent tumours are rare; they consist of osteomata, chondromata, myxomata, lipomata, and fibromata.

Osteomata may be ivory or cancellous. *Ivory osteomata* occur in the region of the neck and condyle of the mandible. The tumour is

usually single and is found as a smooth, hard mass covered with periosteum. Growth is slow, but such tumours may cause limitation of movement at the temporo-mandibular joint. Excision is difficult, and fracture of the neck of the mandible may result if precautions are not taken to prevent this.

Cancellous osteomata are more common than the ivory, and may be met with near the symphysis or in the region of the lingula. Their removal may be difficult owing to the fact that they may be growing from the inner side of the mandible.

Chondromata are occasionally seen; they arise most frequently in the region of the condyle or the symphysis, and may be mistaken, clinically, for osteomata.

Myxomata are very rare tumours in relation to the mandible, and it is quite possible that they may be due to degenerative changes occurring in fibromata, chondromata or lipomata.

Lipomata, when present, are often subperiosteal in situation, and are rarely diagnosed correctly. The tumour is usually very hard and is mistaken for an osteoma, but X-ray examination does not reveal any bony structure. The correct diagnosis is only made on exploration, when the tumour can be completely removed and the diagnosis confirmed by the microscope.

Fibromata may occur in any part of the mandible. They grow from the periosteum and form hard tumours which may become pedunculated if growing from the inside of the jaw, as they then come into contact with the tongue which soon exerts a suction traction action on the tumour. Excision is a simple matter; if left alone they slowly increase in size and later may become sarcomatous.

Malignant tumours are more common and vary considerably in the nature of their malignancy.

Osteoclastoma may occur as an endosteal growth which slowly expands the body of the jaw. It generally presents but slight evidence of malignancy, and may be treated in the first place by opening the outer shell of bone through the mouth, scraping away the soft dusky purple contents and plugging the cavity with gauze, after having swabbed it out with pure carbolic or tincture of iodine. If the case is a late one and the jaw much expanded, the cavity may be filled with bone chips to help the consolidation of the bone. If recurrence takes place, the cavity should be scraped out once more and some radium needles be inserted after the cavity has been filled with bone wax. The needles are left *in situ* for six or seven days; they are then removed together with the wax and the wound allowed to granulate.

Sarcomata form the commonest malignant tumours of the mandible, and every type of osteogenic sarcoma may occur (fig. 2815). The periosteal variety is very malignant and often shows an excessive amount of new bone laid down in radiating laminæ (figs. 2816 and 2817). The best form of treatment is by deep X-ray therapy, but some cases treated with the radium bomb have yielded good results. Excision of half the mandible may be undertaken if suitable X-ray or radium therapy is not available (figs. 2818 and 2819). Small doses of radium or X-rays only aggravate the condition.

Endosteal Sarcoma often arises in the horizontal ramus, and the condition may be mistaken for chronic osteomyelitis, especially if too

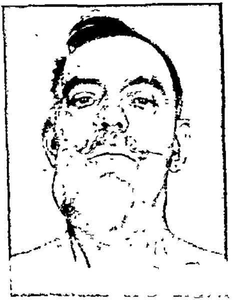

Fig 2815.—Photograph of a man with a periosteal sarcoma of the mandible.

much reliance is placed on the X-ray appearance. In cases of doubt, a biopsy should always be obtained to confirm the diagnosis. Excision of half the mandible may be undertaken, or the case may be treated by deep X-ray therapy.

Secondary Sarcomatous Deposits are rarely seen in the lower jaw. They present as hard masses which, on X-ray examination, often appear to be cystic. Such deposits occur only in the advanced stages of sarcomatosis where secondary deposits are to be found all over the body.

Malignant Melanoma may be seen occasionally, growing from the lower jaw. Some thirty cases are reported in the literature. The growth forms a bluish-black lump growing from the inner or outer surface of the horizontal ramus. Histologically, the tumour is very

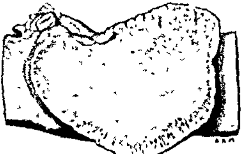

Fig. 2816.—Specimen of a mixed-celled sarcoma of the mandible in a man aged fifty

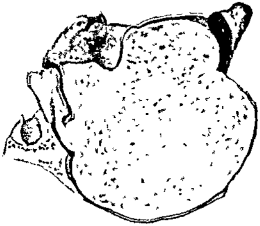

Fig. 2817.—Specimen of a fibro sarcoma of the mandible in a boy aged seven

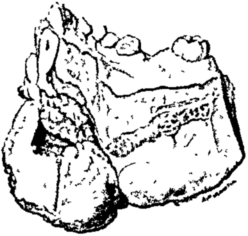

Fig 2818 —Specimen of alveolar sarcoma of the mandible in a man aged thirty one.

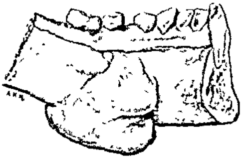

Fig 2819 —Specimen of chondro-sarcoma of the mandible from a man aged thirty-three.

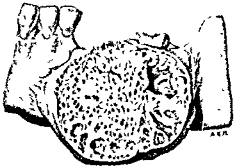

Fig 2820 —Specimen of uncalcified adamantinoma of the mandible.

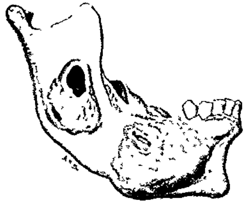

Fig 2821.—Specimen of cystic adamantinoma of the mandible removed by operation from a man aged fifty.

(Drawings from specimens in the Museum of the Royal College of Surgeons.)

cellular, of sarcomatous structure, the spindle cell predominating. Excision of half the jaw should be undertaken.

Carcinoma may invade the jaw from the tongue or the floor of the mouth, and is of the *squamous-celled type. Wide excision of the bone* together with the primary disease is always required, unless it has extended so far as to render extirpation impracticable ; in such cases radium treatment should be undertaken.

Columnar-celled Carcinoma is rare ; it commences in epithelial rests in the peri-odontal membrane and spreads into the jaw. The treatment is similar to that already outlined.

Secondary Carcinoma may occasionally be seen in the jaw in advanced cases of carcinomatosis, the primary disease being in the breast, prostate, thyroid or kidney. The X-ray appearances are characteristic of secondary carcinoma in the long bones (see fig. 2929).

Endothelioma may rarely be seen in the lower jaw. It arises in connection with the blood-vessels and is found growing from the alveolar process. Diagnosis is often difficult, even when a piece has been removed for histological examination. Treatment should consist of local excision of the jaw in the region of the tumour.

Fibrocystic Disease of the Mandible (*Adamantinoma. Epithelial odontome*). This is a rare disease but one which is well known. It is an epithelial tumour arising in connection with the enamel organ and may be regarded as a type of adenoma. The tumour is innocent in nature but spreads into the surrounding bone of the jaw (see fig. 2820). In some cases the tumour undergoes some calcareous degeneration which may readily be seen in an X-ray photograph ; in other cases the whole of the lower jaw may be converted into definite cystic masses (see fig 2821). Histologically the tumour consists of a mass of epithelial-lined spaces surrounded by dense fibrous tissue, this appearance having led to the term fibrocystic. It is not necessary in all cases to remove half the lower jaw, but the tumour should be enucleated.

EXCISION OF THE MANDIBLE

This is an operation which is rarely performed at the present day. Partial excision may be necessary in the removal of epulides ; this generally consists in the resection of a portion of the alveolar border together with the growth.

Resection of the median portion of the lower jaw is undertaken for those cases where there has been an extension from a carcinoma of the under-surface of the anterior part of the tongue, from a carcinoma of the floor of the mouth, or even from a carcinoma of the lip. Before under-

taking such an operation it is very important that all septic foci in the mouth should be removed. Intra-tracheal gas and oxygen is the best form of anæsthesia and allows the pharynx to be plugged with gauze, so that no blood or saliva can enter the air-passages during the operation. The diseased area is enclosed by two incisions which converge in the mid-line just above the hyoid bone. The divided vessels are secured, and the lower jaw is divided by means of a piece of stout catgut or kangaroo tendon which is passed through two drill holes on either side. The skin flaps are undermined and brought together; it may be necessary to relieve the tension of the flaps by some lateral incisions. It is essential to suture the lip carefully so that the red margin on one side coincides exactly with that of the other. Drainage is essential, the tube being placed in the lower part of the incision.

Excision of Half of the Mandible. This operation is performed for cases of malignant disease. Intra-tracheal gas and oxygen anæsthesia

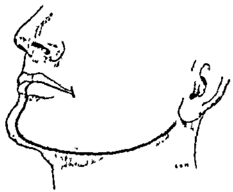

Fig. 2822.—Diagram showing the extent of the incision employed for removal of half the mandible.

and plugging of the pharynx with gauze are imperative. With the head turned to the opposite side, an incision is made commencing in the centre of the lower lip and passing downwards to a point immediately below the symphysis (fig. 2822). It is then carried along the under-surface of the body of the mandible and as far as the angle. The incision is then prolonged upwards along the posterior border of the vertical ramus as far as the lobule of the ear, but no further because of the danger of cutting the facial nerves. While making the incision over the posterior part of the body of the mandible the facial vessels are encountered and secured between ligatures. The large flap is turned upwards and the muscles attached to the jaw which are not involved or in contact with the tumour are elevated by a periosteal elevator (see fig. 2823). The muscles on the inner side of the jaw are dealt with in a similar manner, care being taken that the mucous membrane of the mouth is kept intact. The central incisor tooth is extracted, and the jaw divided through the empty socket with a small saw and cutting

pliers, a little to one side of the middle line. By this means the genial tubercles and their attached muscles are not damaged, and thus the movements of the tongue are unimpaired. The bone is now pulled out-

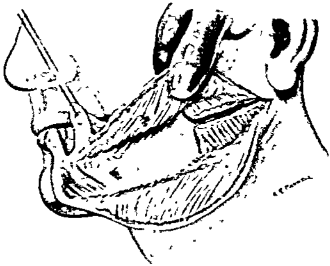

Fig. 2523.—Operation for removal of half the mandible. The skin flap is raised and the masseter muscle cut through.

wards and its internal attachments are brought into view and divided, care being taken to secure the inferior dental vessels just before they enter the canal in the bone. By depressing the jaw the tendon of the

Fig. 2524.—Excision of half the mandible. The bone has been divided in the mid-line and its final muscular attachments are severed.

temporal muscle is exposed and its attachment to the coronoid process can be severed by a few touches with the knife. Lastly, the condyle of the jaw is freed after cutting through the tendon of the external pterygoid muscle and the capsule of the temporo-mandibular joint

(fig. 2824). Care should be taken not to divide the internal maxillary artery which is in close proximity to the inner surface of the neck of the mandible. As a rule, hæmorrhage is quite easily controlled, and the wound can be stitched together with interrupted silkworm-gut sutures —a drainage-tube being inserted at the posterior end. Care should be taken in approximation of the lip so that the red margin is continuous on both sides of the incision. The wound is dressed with gauze in which one or two marine sponges are incorporated to give firm pressure and prevent the occurrence of a hæmatoma. The drainage-tube should not be removed until all oozing has stopped, which is generally about the third or fourth day after the operation. The wound heals well and there is little post-operative pain. The patient may be allowed out of bed on the second day, and can generally leave hospital about the tenth day. Considerable deformity usually results from this operation, owing to the remaining half of the bone being drawn across the middle line, but, if necessary, this can often be overcome by a plastic operation at a later date. The co-operation of a dental surgeon will often help in obtaining a good result by the use of a suitable denture. Although excision of half the lower jaw appears to be quite a simple operation, there are a number of pitfalls which the surgeon should endeavour to avoid: first and foremost, gentleness is all important, as a fracture may result at or near the site of the tumour; the pharynx may be opened if the knife is not kept close to the bone while separating the soft parts from the region of the angle of the jaw; or the internal maxillary vessels may be wounded and give rise to troublesome hæmorrhage which is difficult to locate and control.

LEONTIASIS OSSEA

The lower jaw is frequently involved in this uncommon disease, in fact in some cases it appears to be the first bone of the face to become affected (see figs. 2825, 2826, 2827 and 2828). The bone is enlarged, sclerosed and pitted as if a creeping periostitis had taken place. The jaw appears enlarged in every direction, and the patient is often very conscious of this fact. There is no known treatment for the condition, but small abscesses may form around some septic teeth which are often embedded in a very dense mass of sclerosed bone (see figs. 2829 and 2830). Extraction of the teeth may entail a very difficult surgical operation, the only method by which the teeth can be removed being by means of an electrically-driven burr or chisel.

Fig. 2825.—Photograph of patient with leontiasis ossea—side view.

Fig. 2826.—Photograph of patient with leontiasis ossea—front view.

Fig. 2827.—Skiagram of patient with leontiasis ossea. Same case as shown in *Figs.* 2825 and 2826.

Fig. 2828.—Skiagram of patient with leontiasis ossea. Same case as shown in *Figs.* 2825 and 2826.

OSTEITIS DEFORMANS (PAGET'S DISEASE)

Although the bones of the cranium are commonly affected in this disease, the facial bones and lower jaw show only slight involvement. In a few recorded cases the lower jaw has been markedly affected and

Fig. 2829.—SPECIMEN OF LEONTIASIS OSSEA WHICH IS GENERALISED AND HAS AFFECTED MOST OF THE BONES OF THE SKULL.
(*Museum, R.C.S.*)

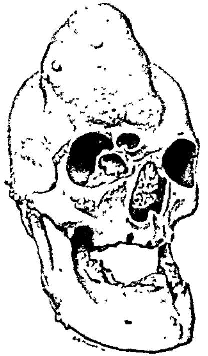

Fig. 2830.—SPECIMEN OF A SKULL SHOWING ISOLATED PATCHES OF LEONTIASIS OSSEA.
(*Museum, R.C.S.*)

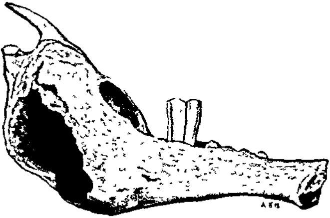

Fig. 2831.—SPECIMEN OF THE MACERATED JAW OF AN ADULT GOAT AFFECTED WITH *OSTEITIS FIBROSA.*
(*Museum, R.C.S.*)

enlarged. On X-ray examination the jaw appears to have cystic spaces connected by multiple trabeculæ throughout its entire length. The dried bone is quite porous.

OSTEITIS FIBROSA

In this uncommon bone disease, which is characterised by the replacement of the osseous framework and contained marrow by

fibrous tissue, the mandible quite often escapes. Some rare cases, however, have been recorded, and figure 2831, which is a macerated lower jaw, shows the interior of the expanded bone to be filled with a spongy or finely granular and excessively friable osseous material. There can be no doubt but that a bony trellis-work passed through the interior of the bone at some period while the disease was in progress.

ACROMEGALY

The lower jaw is often greatly enlarged and elongated in this disease so much so that the teeth in the upper jaw do not come into apposition with those in the lower. When growth has stopped, it may be necessary to excise a portion of the horizontal ramus of the jaw on each side. It is often necessary to remove a portion of the tongue at the same time, as it is partly responsible for the pushing forward of the anterior end of the mandible. The lower jaw may be somewhat misshapen in children suffering from severe rickets, but generally, as the disease is treated, the deformity disappears and no sign of the condition persists in adult life.

In infantile scurvy, there may be subperiosteal hæmorrhages in the lower jaw, and a fracture may occur. Quite often the teeth become loosened and may fall out, which is probably due to the atrophic changes taking place in the osseous walls of the alveoli.

Another disease which may attack the lower jaw is *Mother-of-Pearl Workers' Periostitis*. This disease occurs in mother-of-pearl turners, who appear to be affected by a peculiar periostitis which may attack the long bones and the jaws. The disease is sudden in its onset, but often rapidly fades, leaving a little thickening of the bone, the result of the periostitis. The condition never gives rise to any necrosis, and, as a rule, no treatment is indicated.

A very uncommon condition, of which there are few examples, is a *hydatid cyst* of the lower jaw. The bone is expanded into a thin perforated lamina of bone and a fracture may ensue before the disease ends fatally.

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Section 2

ODONTOMES

An odontome is a tumour composed of dental tissues which are concerned in tooth development. Odontomes must be regarded as tumours since they tend to increase in size, perform no physiological function, have no typical termination, and fulfil Thoma's definition of a tumour, namely, "*an autonomous or independent new growth.*"

There are four different varieties of odontomes:

(1) *Epithelial odontomes*, which are the outcome of abnormal development in the dental epithelium. Under this heading are grouped:

- (*a*) Multilocular cysts.
- (*b*) Eruption cysts.
- (*c*) Dental cysts.
- (*d*) Dentigerous cysts.

Multilocular cysts. Fibrocystic disease of the jaw, or adamantinoma, generally occurs in the molar region of the lower jaw and is more common in females than males. The cystic tumour is of slow

Fig. 2832—Fibrocystic disease of the jaw.

growth and gradually distends the jaw but produces no marked change in the appearance of the mucous membrane. As the tumour grows it tends to become extruded from the outer plate of the alveolar border (fig. 2832). If the tumour is allowed to grow to a large size, a thin layer of bone may cover the cystic spaces of the growth and egg-shell crackling may be elicited.

The histological picture is rather varied, but in general it may be said that the tumour is seen to consist of numerous cavities lined with columnar or spheroidal epithelium separated from one another by fibrous or bony septa. The cysts vary in size and the stroma is made up of dense fibrous or cellular connective tissue. These tumours should be removed by excision; if this involves a large part of the jaw, the defect should be filled with a bone graft.

Cyst of eruption is caused by the delayed eruption leading to the stimulation of remnants of epithelium derived from the tooth band. It usually occurs in young people, and causes a bluish swelling over the tooth. The cyst should be excised, and if the tooth is infected it should also be extracted.

Dental cyst is a very common form, is more often seen in the maxilla than in the mandible, and seems to prefer the region of the first molar tooth. A dental cyst may occur in either sex, and may arise in connection with either deciduous or permanent teeth. These cysts are due to an infection from organisms in the pulp canal of pulpless teeth. In some cases trauma may be the exciting cause, as where a small apical hæmatoma forms and becomes infected.

A dental cyst may arise through the irritation of epithelial cells in the alveolar dental periosteum (the remnants of the epithelial sheath of Hertwig). The actual pathology is of interest insomuch as the cyst begins as a granuloma in which the epithelium proliferates and a so-called "epithelial root tumour" develops. A capsule is formed lined by epithelium which may be squamous, stratified or columnar in type. As the cyst expands, it causes pressure on the bone surrounding it, the result being a bulging of thinned bone, which may become so attenuated that egg-shell crackling may be elicited on examination. X-ray examination invariably reveals a sharp outline to the cyst, except in those cases where an abscess has formed. As a rule there is a zone of rarefying osteitis surrounding the cyst wall. The treatment of a dental cyst demands the extraction of the tooth which has been responsible for the cyst.

For a small dental cyst the cavity should be curetted and swabbed out with tincture of iodine to destroy the epithelial lining. The cavity should be irrigated daily with an antiseptic until healing has taken place.

In the case of large dental cysts where a deep cavity remains and healing would take a long time, a flap of muco-periosteum is raised and then stitched to the bottom of the cyst. Such an operation can only be undertaken where there is no oral sepsis.

Dentigerous cyst is also known as a "follicular odontome" or "cystic follicular odontome" and occurs more frequently in the mandible associated with an unerupted permanent tooth, usually

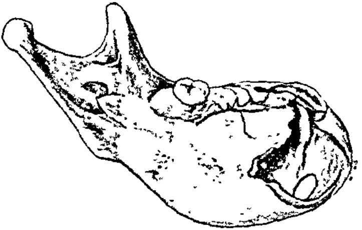

Fig 2833.—Dentigerous cyst showing unerupted tooth.

molar or canine (fig. 2833). It may, however, sometimes be found with a supernumerary and, rarely, with a deciduous tooth. It is quite common to find such a cyst in rickety children.

The cause is, undoubtedly, a primary infection from a deciduous

Fig 2834.—Small dentigerous cyst containing a tooth (natural size) (*Wakeley and Buxton's "Surgical Pathology."*)

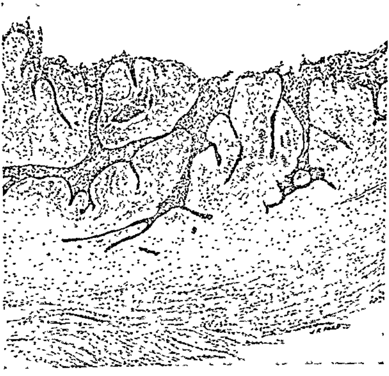

Fig 2835.—Microscopic section of wall of dentigerous cyst shown in Fig 2834 (× 45).
(*Wakeley and Buxton's "Surgical Pathology," Wright, Bristol*)

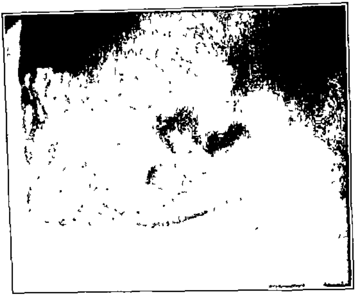

Fig 2836.—SKIAGRAM OF DENTIGEROUS CYST SHOWN IN *Fig* 2834.
(*Wakeley and Buxton's "Surgical Pathology"*)

tooth resulting in the formation of a dental cyst, which, so formed, meets and surrounds the developing unerupted tooth. A large swelling occurs in the jaw, which is painless at first and later causes some chronic pain as expansion of the bone takes place (see figs. 2834–2836). Skiagrams reveal the missing tooth lying within the cyst or in some cases embedded in the cyst wall.

The treatment consists of opening the cyst and removing the infected tooth which was the causative agent. The cavity should be washed out with tincture of iodine and treated as a dental cyst.

Fig 2837.—COMPLEX COMPOSITE ODONTOME REMOVED FROM LOWER JAW
(*Wakeley and Buxton's "Surgical Pathology"*)

Fig 2838.—OSSEOUS ODONTOME COVERING THE CROWN OF A MANDIBULAR MOLAR.
(*Wakeley and Buxton's "Surgical Pathology."*)

Fig 2839.—ENAMEL NODULE ON A MOLAR TOOTH.

(2) *Composite odontomes.* Under this heading are considered those tumours which arise from the whole tooth germ:

(*a*) Complex composite odontome.
(*b*) Compound composite or follicular odontome.

(c) Germinated composite odontome.
(d) Gestant composite odontome.
(e) Enamel nodules or epithelial pearls.
(f) Dilated or cavernous composite odontome.

It will be seen that the composite odontomes form a large section, varying in character, but usually of slow growth, some occurring in man while others are more common in horses and goats (figs. 2837–2839). In the case of the complex and compound composite odontomes, removal is necessary but the other varieties under this heading should be left alone unless infection takes place.

(3) *Connective tissue odontomes.* These are rare in man and may be divided into:

(a) Fibrous odontomes.
(b) Cementomes.

The fibrous odontome resembles a fibroma. It may occur in rickety children, but is much more common in goats. A swelling occurs around a tooth which gradually increases in size but is quite painless.

The cementome is in reality a calcified fibrous odontome, and the tooth or teeth appear to be imbedded in hard calcified tissue (fig. 2840).

Fig. 2840.—Cementome.

Suppuration may ensue, and the whole tumour become detached from the jaw. Excision may be required if much displacement of the jaw takes place.

(4) *Malignant odontomes.* These are very rare, and consist of spheroidal- or columnar-celled carcinomata which have developed in dental tissues. A fibro-sarcoma has been described arising from the dentine germ and called a composite embryoplastic odontome. By

the time these rare tumours are seen the only treatment to be of any avail is some form of radio-therapy.

For a fuller description of the minute pathology and operative technique used in the removal of the various odontomes, reference should be made to books on dental and surgical pathology, one of the most practical being by Widdowson and Widdowson.

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PART XXXIII

FRACTURES OF THE MANDIBLE

by

W. Kelsey Fry

FRACTURES OF THE MANDIBLE

Owing to the conditions of modern life, fractures of the mandible are becoming more frequent, and cases are often admitted into general hospitals under the care of general or orthopædic surgeons. Consequently it has now become essential for the general surgeon to have a thorough knowledge of the principles of the treatment of such cases. Unfortunately, only very scanty mention of fractures of the jaws is made in the standard text-books on general fractures, the apparent reason being that the treatment of this condition lies in a sort of " No Man's Land " between the territories of the general surgeon and the dental surgeon. At the present time there appears to be a tendency for surgeons to postpone any treatment of the fracture until the patient has recovered from shock, concussion, etc., and until the swelling of the soft tissues has subsided. Much valuable time is thus lost, whereas the closest co-operation between the general and dental surgeons at this time would prove extremely beneficial, especially as immediate immobilisation of the fragments is one of the first principles in the successful treatment of these fractures.

The general principles of the treatment of mandibular fractures are similar to those of other fractures in the following particulars :

(1) The earliest possible diagnosis of the site and nature of the fracture must be made, and skiagrams taken at repeated intervals to note progress.

(2) The displacement should be reduced and the correct alignment obtained with as little delay as possible.

(3) Complete immobilisation must be ensured so as to retain the fragments in their correct position.

The principles differ from those of other fractures as follows :

(a) Early active or passive movement (except in fractures involving the head of the condyle or the condylar process) is not necessary for maintaining the healthy condition of the muscles or for restoring functional ability. Complete immobilisation is the foundation of success in these cases, and the action of suction needed for the intake of liquid food is sufficient to maintain the muscles in good tone.

(b) Early surgical methods for the purpose of fixation—wires, screws, plates, etc., are generally contra-indicated, and there is also no call for transfixor rods, calipers, etc.

(c) The fractures are usually compound, and teeth may be present in the line of fracture.

(d) A fixed base for immobilisation is generally provided by the presence of teeth on the separate fragments, and, in the case of fractures of the mandible, the opposing teeth on the maxilla may be utilised for this purpose.

CAUSES OF FRACTURES

The causes of fractures are divided into two classes : (1) Predisposing, and (2) Immediate.

Predisposing causes are either general bone diseases, such as osteitis

fibrosa, or local diseases, such as tumours, cysts and osteomyelitis. Acute osteomyelitis following the extraction of teeth in the mandible is also a frequent cause, the usual history of such a case being: Infection followed extraction of teeth, treatment was delayed and acute osteomyelitis resulted; the jaws were not splinted and a pathological fracture ensued. The lesson to be learnt from these cases is the necessity to splint all cases of extensive osteomyelitis so as to avoid possible fracture, thus retaining the periosteum in its normal extended position so that new bone may be formed in correct alignment. When it is considered that surgical fractures are liable to occur, close co-operation between the general and dental surgeons is necessary, so that the latter may construct splints before the operation to retain the fragments in as good alignment as possible and thus reduce facial deformity to a minimum. The absence of this co-operation often results in the fragments being displaced and bound down by scar tissue, subsequent treatment being prolonged and rendered difficult.

Immediate causes are various forms of violence, and result in direct or indirect fractures. If a blow is received on the side of the mandible, a direct fracture may occur at the site of injury together with an indirect fracture on the opposing side of the jaw close to the unerupted wisdom tooth or the neck of the condyle. In some cases no direct fracture occurs at the site of injury, e.g. a fall upon the chin with the instinctive clenching of the teeth may result only in indirect fractures of one or both necks of the condyles.

Location of Fractures.

Fractures may occur in any part of the mandible, but usually take place in the body of the jaw, as this part has only a thin covering of soft tissue and is more exposed to injury. The commonest sites of fractures are in the molar region, the premolar region, and the necks of the condyles, in the order named. In locating the site of fracture it must be remembered that a violent blow will often cause an indirect fracture on the opposite side of the mandible, usually in the canine region, due to the resilience of the mandible and its great convexity in this area. This fracture will often be accompanied by an indirect fracture of the mandible on the side on which the blow was received, at the neck of the condyle, or through the site of the unerupted wisdom tooth—the two inherent points of weakness. Other frequent sites of fractures are the canine and incisor regions. In young children the commonest site is the canine region owing to the unerupted permanent canine being situated near the lower border of the mandible, with consequent weakness in that region.

DIAGNOSIS

In most cases of mandibular fractures diagnosis is simple and may be made by inspection alone. The usual symptoms of pain, tenderness, swelling, crepitus, etc., are present, in addition to which the patient complains of difficulty in opening or closing the mouth, and there is derangement of the natural line of the teeth, with congestion and discolouration of the mucous membrane around the fractured area. There may also be a marked deformity in the symmetry of the face and consequent lack of control of the saliva, and it may be found that some of the teeth in the fractured area have been lost. Crepitus may be determined by grasping the mandible on either side of the suspected fracture using the thumb and forefinger of each hand. In cases of fracture of the ascending ramus or of the condylar region, some of the usual symptoms are often absent, and the condition is suspected

by the deviation of the mandible to the affected side on opening the mouth. Crepitus in these cases is difficult to elicit, except by means of a stethoscope over the suspected area or by placing the little fingers in the external auditory meati and comparing the movements of the condyles on the two sides. X-ray confirmation is essential in all cases to give the exact location and direction of the fracture and the relation of the teeth to the fractured area. The radiographs should be taken in the antero-posterior and the right and left lateral positions.

Displacement.

When deformity is present it is due to the displacement of the fragment, and the type of this displacement depends largely upon the direction and force of the injury and upon the direction of the line of fracture, together with the resultant action of the muscles attached to the separate fragment. The presence or absence of teeth also influences the amount of displacement. By noting the type of displacement the site of injury may generally be diagnosed. It must be remembered that there are three main groups of muscles attached to the mandible, viz. elevators, depressors, and rotators, and the direction of the displacement depends upon the line of fracture and the predominance of one of these groups of muscles acting on the separate fragment (see fig. 2841).

Various types of fractures present characteristic displacements, such as:

(1) *Fractures in the symphysis region.* When there is no loss of bone, the muscular groups remain balanced and no displacement occurs. If, however, there is comminution, the two main fragments are inverted and drawn towards the mid-line.

(2) *Fractures in the premolar region.* When the injury is slight and sufficient teeth are present in the mandible and maxilla, the displacement will be slight owing to the action of the teeth. If there is a scarcity of teeth and the force of injury is great, marked deformity will occur, the amount depending upon the line of fracture. When the line of fracture is vertical, the small posterior fragment will be displaced upwards, the larger fragment being displaced downwards by the action of the depressor muscles attached to this fragment. The line of fracture in this region is, however, usually oblique, and in this case the displacement is accentuated by the resultant overlapping of the fragments, due to the action of the external pterygoids (see fig. 2842).

(3) *Fractures in the molar and angle regions.* Fractures in these regions are not only greatly influenced by the presence or absence of teeth on the small posterior fragment, but also by the obliquity of the line of fracture which generally occurs here as in the case of the premolar region. Figure 2843 shows the different lines of fractures frequently met with, and it will be noted that when the line of injury runs from above downwards and backwards (as A in fig. 2843) displacement is more likely to occur than when the line of fracture runs from above downwards and forwards (as B in fig. 2843), as in the latter case the elevator muscles are less able to displace the fragment in an upward direction. Again, if there is a tooth on the smaller fragment this will tend further to resist displacement, and should there be a maxillary tooth present to oppose this tooth, displacement may be entirely prevented (see fig. 2844). If the fracture runs in the direction of A and no teeth are present, the posterior fragment will be displaced upwards by the elevators and forwards and inwards by the rotators (external pterygoids), the larger fragment being depressed and the mid-line of the mandible diverted to the injured

fibrosa, or local diseases such as tumours, cysts and osteomyelitis. Acute osteomyelitis following the extraction of teeth in the mandible is also a frequent cause, the usual history of such a case being: Infection followed extraction of teeth, treatment was delayed and acute osteomyelitis resulted; the jaws were not splinted and a pathological fracture ensued. The lesson to be learnt from these cases is the necessity to splint all cases of extensive osteomyelitis so as to avoid possible fractures, thus retaining the periosteum in its normal extended position so that new bone may be formed in correct alignment. When it is considered that such fractures are liable to occur, close co-operation between the general and dental surgeons is necessary so that the latter may construct splints before the operation to retain the fragments in as good alignment as possible and thus reduce facial deformity to a minimum. The absence of this co-operation often results in the fragments being displaced and bound down by scar tissue, subsequent treatment being prolonged and rendered difficult.

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DIAGNOSIS

In most cases of mandibular fractures diagnosis is simple and may be made by inspection alone. The usual symptoms of pain, tenderness, swelling, crepitus, etc., are present, in addition to which the patient complains of difficulty in opening or closing the mouth, and there is derangement of the natural line of the teeth, with congestion and discolouration of the mucous membrane around the fractured area. There may also be a marked deformity in the symmetry of the face and consequent lack of control of the saliva, and it may be found that some of the teeth in the fractured area have been lost. Crepitus may be determined by grasping the mandible on either side of the suspected fracture using the thumb and forefinger of each hand. In cases of fracture of the ascending ramus or of the condylar region, some of the usual symptoms are often absent, and the condition is suspected

by the deviation of the mandible to the affected side on opening the mouth. Crepitus in these cases is difficult to elicit, except by means of a stethoscope over the suspected area or by placing the little fingers in the external auditory meati and comparing the movements of the condyles on the two sides. X-ray confirmation is essential in all cases to give the exact location and direction of the fracture and the relation of the teeth to the fractured area. The radiographs should be taken in the antero-posterior and the right and left lateral positions.

Displacement.

When deformity is present it is due to the displacement of the fragment, and the type of this displacement depends largely upon the direction and force of the injury and upon the direction of the line of fracture, together with the resultant action of the muscles attached to the separate fragment. The presence or absence of teeth also influences the amount of displacement. By noting the type of displacement the site of injury may generally be diagnosed. It must be remembered that there are three main groups of muscles attached to the mandible, viz. elevators, depressors, and rotators, and the direction of the displacement depends upon the line of fracture and the predominance of one of these groups of muscles acting on the separate fragment (see fig. 2841).

Various types of fractures present characteristic displacements, such as:

(1) *Fractures in the symphysis region.* When there is no loss of bone, the muscular groups remain balanced and no displacement occurs. If, however, there is comminution, the two main fragments are inverted and drawn towards the mid-line.

(2) *Fractures in the premolar region.* When the injury is slight and sufficient teeth are present in the mandible and maxilla, the displacement will be slight owing to the action of the teeth. If there is a scarcity of teeth and the force of injury is great, marked deformity will occur, the amount depending upon the line of fracture. When the line of fracture is vertical, the small posterior fragment will be displaced upwards, the larger fragment being displaced downwards by the action of the depressor muscles attached to this fragment. The line of fracture in this region is, however, usually oblique, and in this case the displacement is accentuated by the resultant overlapping of the fragments, due to the action of the external pterygoids (see fig. 2842).

(3) *Fractures in the molar and angle regions.* Fractures in these regions are not only greatly influenced by the presence or absence of teeth on the small posterior fragment, but also by the obliquity of the line of fracture which generally occurs here as in the case of the premolar region. Figure 2843 shows the different lines of fractures frequently met with, and it will be noted that when the line of injury runs from above downwards and backwards (as A in fig. 2843) displacement is more likely to occur than when the line of fracture runs from above downwards and forwards (as B in fig. 2843), as in the latter case the elevator muscles are less able to displace the fragment in an upward direction. Again, if there is a tooth on the smaller fragment this will tend further to resist displacement, and should there be a maxillary tooth present to oppose this tooth, displacement may be entirely prevented (see fig. 2844). If the fracture runs in the direction of A and no teeth are present, the posterior fragment will be displaced upwards by the elevators and forwards and inwards by the rotators (external pterygoids), the larger fragment being depressed and the mid-line of the mandible diverted to the injured

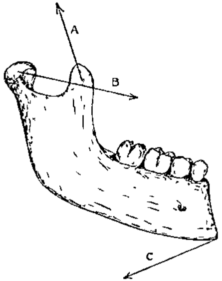


Fig. 2841.—DIAGRAM TO ILLUSTRATE ACTION OF MUSCLES ATTACHED TO MANDIBLE.
A. Elevators B. Rotators C. Depressors.

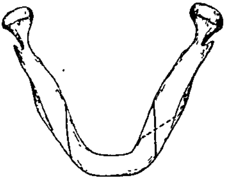


Fig. 2842.—OBLIQUITY OF FRACTURES IN PREMOLAR REGION.

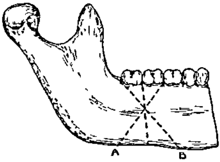


Fig. 2843.—LINES OF FRACTURES IN MOLAR REGIONS.

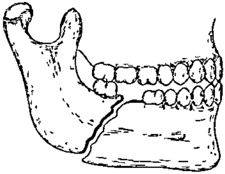


Fig. 2844.—FRACTURE IN MOLAR REGION WITH TOOTH ON POSTERIOR FRAGMENT PREVENTING DISPLACEMENT.

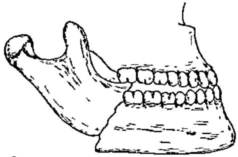


Fig. 2845.—FRACTURE IN MOLAR REGION WITH ABSENCE OF TEETH ON POSTERIOR FRAGMENT, SHOWING UPWARD AND INWARD DISPLACEMENT.

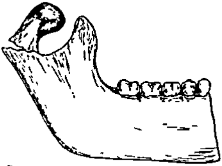


Fig. 2846.—FRACTURE OF THE NECK OF THE CONDYLE.

side (fig. 2845). From the above it will be seen that it is advantageous to conserve for a time a tooth upon the posterior fragment, even though it may be involved in the fracture. *When fractures in these regions are accompanied by loss of bone*, the chances of displacement are naturally greater, but advantage may be taken of the swinging forward of the posterior fragment to assist in obtaining union, care being taken, however, that this fragment does not swing too far upwards and so lose contact with the main fragment.

(4) *Fractures in the condylar regions.* Fractures of the neck of the condyle are very common, and the smaller fragment may be displaced forwards on to the eminentia articularis inwards or outwards; the former is the more usual, being the position occupied by the fragment when the fracture is indirect and is accompanied by direct injury to some other part of the mandible (fig. 2846). If, on the other hand, all the force is taken by the condyle, as in a fall on the chin with teeth clenched, the condyle is forcibly displaced externally so that it may be felt with the fingers, or it is displaced directly inwards, the former being the more common. In all cases of fractured condyles on one side only, the main fragment is displaced towards the injured side, but in the case of a double fracture, it is depressed and the patient presents the obvious deformity of the open bite.

(5) *Fractures of the coronoid process.* These fractures are always due to direct injury, the process being pulled upwards and backwards by the temporal muscle. There is usually no deformity, but pain is referred to this region on opening the mouth.

(6) *Double fractures.* A common injury to the mandible is a double fracture in the premolar regions, resulting in a typical marked deformity, the middle fragment generally being displaced downwards and backwards and the two side fragments upwards and towards the mid-line, the amount of displacement depending upon the obliquity of the lines of fracture (fig. 2847). The backward displace-

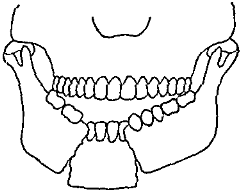


Fig. 2847.—Double fracture in premolar regions showing displacement.

ment of the middle fragment may seriously interfere with respiration and, owing to the loss of control of the tongue, swallowing becomes difficult, the patient being unable to control the saliva, with resultant dribbling.

EMERGENCY TREATMENT

Emergency treatment is fortunately not often called for in cases of mandibular fractures, except where there is comminution in the incisor regions or double fractures in the canine or premolar regions, when the tongue is liable to fall back and interfere with respiration. Immediate holding forward of the tongue then

becomes a necessity and care should be taken not to allow the patient to lie upon the back. If placed upon a stretcher he should lie upon his stomach with the head hanging forward over the end of the stretcher, so that gravity will hold the middle fragment forward until a more permanent method is available to maintain the tongue in a forward position. Neglect of this precaution has resulted in deaths through asphyxia.

TREATMENT

As in the case of fractures of other bones, treatment should be commenced as early as possible, and, as previously stated, the closest co-operation should exist between the general and the dental surgeons to ensure that any displacement is corrected and the fragments immobilised without undue delay. The accurate correction of displacement is more essential in these fractures than in the case of fractures of other bones, as, owing to the presence of teeth, any inaccuracy will cause faulty occlusion and consequent loss of masticatory power.

Control of sepsis It is of the greatest importance that any sepsis in the mouth should be minimised by: (*a*) Irrigation; (*b*) Removal of any septic teeth and teeth in the line of fracture; and (*c*) Establishment of drainage.

(*a*) *Irrigation* A solution of bicarbonate of soda will be found most beneficial in freeing the mouth from mucus and debris, and may be followed by an antiseptic, such as eusol. These washes should be frequently used by means of a Higginson syringe, and particularly after meals.

(*b*) *Removal of any septic teeth and of teeth in the line of fracture.* In order to free the mouth from sepsis it is essential to remove all septic teeth. The treatment of teeth in the line of fracture has aroused much controversy but the general trend of modern opinion favours the removal of these teeth at the first opportunity. Lines of fracture are open pathways for the spreading of an infective process, and when teeth are in these lines a secondary inflammatory condition of the periodontal membrane ensues, and the epithelial attachment between the buccal mucous membrane and the teeth is broken, resulting in pockets being formed which always prove a source of sepsis and deter bone formation. In a large number of cases under observation it has been remarkable to notice the rapidity with which fractures have united after the teeth involved have been removed; on the other hand, it has been equally noticeable, in examining by radiography old injuries which have not united, that although the fragments have been in good alignment, a tooth has been found in the line of fracture, on the removal of which union has rapidly taken place Fractures will sometimes unite with teeth in the line of fracture, even when there is considerable sepsis, but the time taken is prolonged and the chances of pseudo-arthrosis much increased, whilst the teeth have eventually to be removed owing to chronic periodontitis. It has often been observed that when a tooth has been left in the line of fracture it has resulted in an increased loss of bone from sepsis, with the result that the adjacent tooth becomes involved. Sometimes, as previously stated, a tooth is retained on the posterior fragment of the mandible, although, at first examination, removal seems indicated. It must, however, be remembered that it is extremely important to retain a molar tooth so that it may be utilised for the purpose of immobilising the small posterior fragment, which is otherwise difficult to control. In this event the benefit of retaining the tooth, even for a time, outweighs the septic risks, but skiagrams should be taken at intervals to note the condition of the area around the tooth.

Although radical treatment for septic teeth is advocated, it must be borne in mind that, wherever possible, teeth must be conserved for probable use in retention of a prosthetic appliance at a later date.

(c) *Establishment of drainage.* In severe injuries abscess formation often occurs, particularly in the angle region, and when an external wound is present, use should be made of it for drainage purposes. In cases where there is no injury of the soft parts it is often advisable to establish submaxillary drainage as a preventive measure, care being taken to make the incision as inconspicuous as possible.

Retention of Loose Fragments.

The recuperative powers of the mandible are great, and therefore it cannot be too strongly emphasised that no fragments of bone should be removed unless they are obviously necrotic, as these particles may become centres of ossification for the formation of new bone.

Fig 2848.—Barrel bandage.

Fig 2849.—Hamilton strap. (Guy's Hospital pattern.)

Methods of Reduction and Immobilisation of Fragments.

The immediate treatment for the immobilisation of the fragments is by means of bandages, although this is only of a temporary nature and in no way assists reduction. Bandages support the mandible, thus relieving pain by limiting movement, assist in the taking of food, and minimise the dribbling which is so distressing in more serious cases. Bandages also aid in the retention of dressings when necessary.

The most common type of bandage used is the four-tailed bandage, but this type is contra-indicated, as it causes a backward pressure on the fragments, thus tending to increase the displacement in certain cases. The best types are those that provide pressure in an upward and, if possible, forward direction, such as (a) Barrel bandage, (b) Hamilton strap, and (c) Fry's elastic support.

(a) *Barrel Bandage.* This is made with 1½-inch bandage and is applied as shown in figure 2848. Care should be taken to have the posterior loop below the occiput. It is simple and easily adjusted, and applies pressure in an upward direction.

(*b*) *Hamilton Strap* (Guy's Hospital Pattern). This bandage is composed of strips of webbing, 1¼ inches wide, with a linen rest for the chin. The linen is split laterally for three-quarters of its length. To the upper and narrower part are fixed tapes which tie behind, while from the lower part pieces of webbing are taken up in front of the ears and through slots in a band which goes round the head over the forehead The two side bands, and a third piece which comes over the back of the head are joined to three buckles on the crown. Figure 2849 shows the strap in position The main pressure is taken in an upward direction by the vertical bands The two tapes passing backwards are merely to hold any necessary dressing in position and there is no backward pull.

(*c*) *Fry's Elastic Support* Figure 2850 shows this adjustable appliance, which is constructed of elastic and applies pressure in an upward direction.

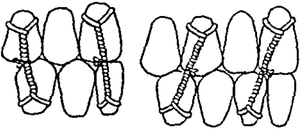
Fig 2850.—FRY'S ELASTIC SUPPORT.

The early treatment with bandages is followed by treatment of a more permanent character for the reduction and immobilisation of the fragments. The methods employed are (*a*) Inter-dental Wiring, (*b*) Splints, (*c*) Wiring, and (*d*) Circumferential Wiring

(*a*) *Inter-dental Wiring.* Utilising the maxillary teeth as a fixed base and wiring to them the teeth on the mandibular fragments is the principle underlying inter-dental wiring. It is owing to the presence of teeth that the method of fixation for jaw fractures differs from that for other bones. For the success of this method of fixation it is necessary to have sufficient teeth on the maxilla and on each fragment of the mandible. The technique of wiring has been greatly improved in recent years. The old method consisted of attaching separate brass wires to the necks of opposing teeth and twisting the ends of these wires together so as to bring the mandibular teeth into correct alignment with the maxillary teeth. Figure 2851 shows the various methods formerly used in inter-dental wiring; Type B is to be preferred to Type A, as in the latter case the tension, being in a vertical direction, has a tendency to loosen the teeth, whereas in Type B the pressure is taken in a more lateral direction. These methods may still be used in cases where the displacement is slight, but they have the disadvantage that if one of the wires breaks it cannot be refixed without all the remaining wires being removed and

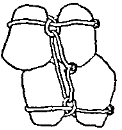
adjusted. Another disadvantage is that if the mouth has to be opened for any purpose, such as inspection or the removal of a tooth, new wires have to be applied.

These disadvantages may be overcome by the use of the American method of inter-dental wiring, known as *eyelet wiring* (fig. 2852), the technique of which is as follows: Under a general anæsthetic, after the necessary teeth have been



A. B

Fig. 2851.—Types of inter-dental wiring.



C

Fig. 2852.—Eyelet wiring.

removed, two adjacent teeth are wired together with a small loop between them, and the same is done to two opposing teeth. The two loops are then joined together with a separate piece of wire. Three of these groups of wires are generally used,

Fig. 2853.—Construction of eyelet wiring.

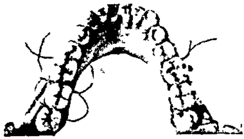


Fig. 2854.—Construction of eyelet wiring.

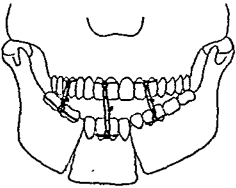


Fig. 2855.—Reduction of displacement by eyelet wiring.

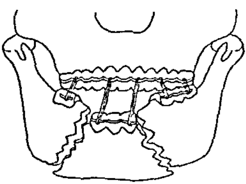


Fig. 2856.—Immobilisation by splints.

one in the centre and one on each side of the mandible. Pieces of brass wire, 24 gauge and about 12 inches in length, are supplied for this purpose by the S. S. White Dental Depot. The wire is first twisted around a dental burr, or some small surgical instrument, to form an eyelet, and the ends are then passed from the buccal to the lingual or palatal surface between the selected teeth. One end of the wire is then passed round the posterior tooth and the other around the anterior tooth

and brought to the buccal surface. Finally, one end is passed through the eyelet and twisted tightly to the other end. The first twist of the wire should be made by the hands and completed by means of pliers, the ends then being cut short and turned between the teeth to avoid irritation of the cheeks. Care should be taken that the eyelet is not too large and is kept as close as possible to the teeth. When all the groups of wires have been fitted and the patient is in a relaxed condition, the displacement is forcibly reduced and, whilst pressure is maintained from below the mandible, the inter-dental wires are inserted in the eyelets and firmly fixed (see figs 2853 and 2854)

The advantage of this method is that if total reduction of the displacement is not possible at the first attempt, as is often the case, the inter-dental locking wires may be tightened daily until reduction is complete (see fig. 2855). Again, should one of these wires break it may be separately replaced, or all the locking wires may be removed for opening the mouth for any purpose without removing the eyelets

(b) *Splints* Dental splints are used on the same principle as inter-dental wiring, viz. the utilisation of the maxillary teeth as a fixed basis for reducing displacement and immobilising the mandibular fragments in their correct position. The best type of splint is the metal cap splint, consisting of metal caps constructed

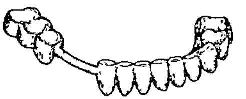


Fig 2857.—Mandibular metal-cap splint.

to fit accurately on the maxillary teeth and the teeth on the separate fragments of the mandible The splints are cemented on to the teeth and have small metal loops attached to the buccal or labial aspects for the purpose of wiring them together (see fig 2856)

Dental splints are used in preference to inter-dental wiring when there are only a few teeth present on the separate fragments, as the attachment is more secure in these cases, thus permitting greater force to be used. Splints are also advisable when the injury is slight and the displacement can be reduced without difficulty. In such cases a splint may be constructed for the mandible only, thus enabling the patient to open and close the mouth normally (fig. 2857).

Much ingenuity has been expended in devising many variations of the metal-cap splint, depending upon the amount of bone lost or the absence of teeth on one or more fragments. In edentulous cases the vulcanite Gunning splint is sometimes used This splint consists of vulcanite plates made to fit the mandible and maxilla and united by means of vulcanite supports. The upper plate is fitted over the maxilla, and the fractured mandible is held in its correct position by the lower plate assisted by a head bandage under the chin.

(c) *Wiring.* Early surgical wiring is contra-indicated because mandibular fractures are usually compound, and because it is extremely difficult to obtain satisfactory occlusion of the teeth by this method. In fractures of the ascending ramus or condylar region which are not compound, union is easily obtained with satisfactory functional results without recourse to surgical wiring. Simple

fractures in edentulous cases also yield good results without wiring, but there is no actual contra-indication.

Wiring is often very useful in cases of non-union of old fractures when all sepsis has subsided, especially in the molar region when the edentulous posterior fragment is displaced forwards and upwards with resulting loss of contour. Silver wire is generally used, and the fragments are dissected and replaced in their normal positions, care being taken not to make an opening into the mouth.

(*d*) *Circumferential Wiring.* This type of wiring is sometimes used when comminution occurs in edentulous or nearly edentulous cases, and consists of passing a wire by means of a cannula through the soft tissues close to the bone on the inside of the mandible, the wire being brought to the external surface of the skin. It is then passed upwards through the soft tissues into the buccal sulcus and the two ends of the wire are twisted over a small vulcanite plate previously constructed to fit the fragments in the correct position. These wires are well tolerated and in suitable cases give excellent results, a typical example being a comminuted fracture in the incisor region with the two lateral fragments edentulous, when these fragments would naturally collapse towards the mid-line. By means of the circumferential wiring the two lateral fragments may be replaced and maintained in their correct position whilst the comminuted area consolidates.

Feeding.

It will be readily understood that the question of satisfactory feeding plays an important part in the treatment of these cases, especially when the jaws are immobilised and mastication is impossible. The usual method is to attach a piece of rubber tubing about 4 inches in length to the nozzle of a feeding cup and to pass the food into the mouth through the tube. In most of these cases teeth in the line of fracture have been lost, which provides a gap through which the tube may be passed, but if all the teeth remain food may be taken by passing the tube behind the last molar tooth. The basis of the diet consists of liquids (or in some cases semi-liquids) in the form of milk, eggs, fruit juices, soups, cereals, etc., which should be varied as much as possible. Fruit and vegetable purées and finely minced meats may also be introduced when circumstances permit, especially in cases where inter-maxillary fixation is not required.

Anæsthesia.

As previously mentioned, a general anæsthetic is usually advisable for cleaning up the mouth, reducing the displacement, and fixing inter-dental wiring. Care has to be taken, especially in severe cases, owing to the difficulty of maintaining an airway, the intra-nasal technique being very valuable. A stout stitch should be put through the tongue and maintained in position until the patient has recovered consciousness, especially in all cases of inter-maxillary fixation. Fear is often expressed as to the possibility of asphyxiation as the result of post-operative vomiting after inter-dental wiring, but this fear is groundless as there is ample room for the expulsion of the vomit. The only disadvantage of a general anæsthetic is the strain placed upon the inter-dental wires during the patient's recovery from the anæsthetic; this strain must be diminished by means of firm bandages, or, preferably, by strapping.

Skiagrams.

In treating fractures of the mandible, skiagrams are essential (*a*) for correct diagnosis, (*b*) to ascertain if teeth are present in the line of fracture, and (*c*) to

ascertain the direction and amount of displacement. Repeated films should be taken to note the correction of displacement and the progress of union. For correct diagnosis all skiagrams should be taken extra-orally and in the antero-posterior and right and left lateral positions. The antero-posterior position is very valuable in giving a general view and indicating the obliquity or otherwise of the line of fracture, but care must be taken not to obscure the condylar area by the mastoid region. The lateral views are invaluable for the definite indication of the line of fracture and the teeth involved, but care must again be taken to prevent superimposition of the two sides of the mandible. Intra-oral films are only of value for small alveolar fractures or isolated fractured teeth.

Treatment of Various Types of Fractures

As previously stated, the presence of a good complement of teeth aids considerably in the successful treatment of mandibular fractures. When, however, the fracture is posterior to the last standing tooth, or teeth are absent on one or more of the fragments, the treatment is less simple, and each individual case requires special consideration. It is therefore desirable to describe the treatment used in certain types of cases.

(1) *Fractures of the alveolar portion only.* This is a very common type, occurring chiefly in the incisor region, where the alveolar bone is thin, both on the lingual and buccal aspects of the teeth, the line of fracture being generally at the level of the apices of the teeth. If the fragment has not been grossly displaced, the blood supply to the teeth is not interfered with, in which case immediate reduction of the displacement and splinting of the fragment in its corrected position is indicated. If the displacement is great and the blood supply to the pulps of the teeth interfered with, it is advisable to remove the fragment *in toto*, the teeth being replaced later by a denture. Care must be taken when removing the fragment to reflect the muco-periosteum from the fragment and to suture the two flaps together, thus avoiding adhesion of the mucous membrane of the lips or cheek to the mandible, with resultant difficulty in retention of the denture.

(2) *Fractures behind the last standing tooth.* In these cases the posterior fragment cannot be successfully controlled, and as this fragment has a tendency to be displaced upwards and inwards, it becomes necessary to bring the main fragment into as good alignment as possible with the small posterior fragment. For this purpose the main fragment is immobilised by eyelet wiring or splinting to the maxilla in the closed bite position. If the fracture is in the angle region it is often not compound, in which case immediate surgical wiring is often advisable. If this method is adopted the main fragment should be firmly immobilised to the maxilla in the corrected position before the operation, otherwise union may be obtained in mal-occlusion.

(3) *Fractures of the neck of the condyle.* In these fractures the condylar fragment may be displaced forwards, inwards or outwards, the first being by far the most frequent. No attempt should be made to replace the smaller fragment but a false joint aimed at, as the functional loss is almost negligible. The treatment of this type of case consists in immobilising the mandible to the maxilla for five to seven days, and then encouraging movement. To prevent the tendency of the mandible to swing to the affected side a metal-cap splint with a vertical flange (fig. 2558) is fixed to the lower teeth. This splint is worn until such time as

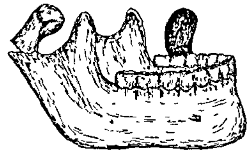
the deflection is corrected by the co-ordination of the muscles. Should the condyle be displaced outwards and so cause deformity of the face, it is advisable to resect the small fragment at a later date.

(4) *Fractures of the coronoid process.* No fixation is required in this type of case, but active movement must be encouraged from the commencement of treatment. These fractures are frequently accompanied by fractures of the zygomatic arch, and if early movement is not encouraged adhesions form, resulting in limitation of movement of the mandible.

(5) *Fractures of edentulous mandibles.* In the majority of fractures of edentulous mandibles without loss of bone, the fractures are not compound, and as no teeth are present the displacement is not pronounced and any slight overlap of the fragments will not greatly interfere with the wearing of a denture. For this reason this type of fracture gives good functional result without any attempt being made to reduce the displacement or immobilise the fragments, a barrel bandage being applied to relieve pain. If there is loss of bone, circumferential wiring must be resorted to in order to maintain the fragments in their correct position and thus avoid marked deformity.

(6) *Fractures of the mandible with edentulous maxilla.* (*a*) With teeth on

Fig. 2858.—Metal-cap splint with vertical flange.



both fragments. A lower metal-cap splint is fitted to maintain the fragments in their correct position. (*b*) With teeth on one fragment only. The general principle is the same as when maxillary teeth are present, except that a vulcanite plate, with thick vulcanite blocks to represent the teeth, is made to fit the maxilla. A lower metal-cap splint is then fitted to the fragment with teeth present and held in its correct position by a barrel bandage against the grooves in the blocks representing the maxillary teeth.

(7) *Comminuted fractures.* The general principle of treatment for these fractures is to immobilise the main fragments to the maxilla in their correct position by eyelet wiring or splinting in order to allow the small fragments to unite. The mandible has remarkable recuperative power, and if the periosteal sheath is stretched out into its correct position the small particles of bone will form new bone and so unite the mandible without loss of contour. Immediate sub-mental or sub-maxillary drainage is advisable in these cases as a precautionary measure against loss of bone through sepsis

(8) *Fractures with loss of bone in the fractured area.* When there is complete loss of bone in the fractured area, the fragments must either be allowed to approximate or be immobilised in their correct positions to await bone graft operation. The choice of these procedures depends upon the site of fracture, the amount of bone lost, the number of teeth present, and the age of the patient. When the

fracture is in the angle or incisor regions considerable nicety of judgment is required. If in the former region, there is often considerable loss of bone due either to the cause of injury or to resultant sepsis, but advantage may be taken of the fact that the main posterior fragment is pulled forwards and upwards by muscular action. This movement should be encouraged, and, if necessary, the last upper molar tooth extracted for this purpose, care being taken that the posterior fragment does not lose contact with the main fragment. Gaps of $\frac{1}{2}$-inch to $\frac{3}{4}$-inch may be made good by taking advantage of this movement of the posterior fragment. The only disadvantage that may accrue from this method is loss of contour of the face in the angle region and it should consequently not be adopted in patients to whom appearance is of primary importance. If the fracture is in the incisor region and the mandible is edentulous or nearly so, approximation to the extent of $\frac{3}{4}$-inch can be carried out without any marked loss of function. If, on the other hand, there are teeth on the two main fragments and the patient is of suitable age, the two fragments should be brought into their normal position and immobilised to the maxilla to await subsequent bone graft operation.

OLD FRACTURES

Cases often present themselves for treatment of old fractures showing (*a*) Delayed union, (*b*) Non-union, or (*c*) Malunion.

(*a*) *Delayed union.* This condition is invariably due to sepsis or insufficient immobilisation, the former being the chief cause, and is generally the result of a tooth or a small sequestrum being left in the line of fracture. Removal of the cause and provision of efficient immobilisation will invariably ensure union.

(*b*) *Non-union.* Non-union of mandibular fractures is usually due to eburnation of the fractured ends, or to loss of bone due to the injury or subsequent sepsis. If from the former cause, a thorough freshening of the ends of the fragments, together with efficient splinting, is usually sufficient to ensure union, but it may be necessary to add a small piece of fresh bone if the space between the two ends warrants such a course being adopted. When the non-union is due to loss of bone, and the loss is such that approximation of the fragments is not indicated, the main fragments must be replaced in their correct position by mechanical or surgical means, held in that position for at least six months after the last signs of sepsis, and union then obtained by a bone graft operation.

(*c*) *Malunion.* When owing to the lack of treatment union has taken place in a faulty position resulting in mal-occlusion of the teeth and loss of contour of the face, the treatment must be directed towards the correction of these faults. If the defect is not great, better occlusion of the teeth may be obtained by judicious grinding or extraction of some of the remaining teeth. If the mal-occlusion is gross and the appearance badly affected, re-fracture of the jaw must be resorted to and the fragments re-united in their correct position. If after re-fracture a bone graft is considered advisable owing to loss of bone, the fragments should be immobilised and held in their correct position until the operation is performed.

PART XXXIV

TEETH

by

C. Bowdler Henry

Chapter I

Disorders of Dentition—Impactions

Chapter II

Injuries and Diseases of the Teeth

Chapter III

Diseases of the Gums and Periodontal Membrane

TEETH

CHAPTER I

Disorders of Dentition—Impactions

INTRODUCTION

The teeth, being largely ectodermal structures, and cradled by the jaws for utility rather than forming an intrinsic part of them, are subject to those pathological changes of congenital and systemic origin which affect both epiblastic and mesoblastic tissues. When ectodermal development is at fault, the teeth themselves like the hair and nails are either imperfectly developed or completely absent; when faults arise in skeletal development, the teeth share in the disorder by being malformed or, if normal, by finding insufficient room in the jaws for proper eruption. Lastly, in diseases overcoming the adult skeleton they may become prematurely loosened and shed. The following list shows these conditions, which for the most part are of pathological interest rather than of practical importance in oral surgery and will not again be referred to:

(1) *Congenital and Developmental*: Osteogenesis imperfecta, achondroplasia, cranio-cleido-dysostosis, dwarfism, cretinism, gigantism, infantilism, progeria, congenital ectodermal dysplasia. (2) *Nutritional*: Scurvy, rickets, osteomalacia. (3) *Endocrine and Systemic*: Hyperthyroidism, hypothyroidism, cretinism, myxœdema, hyperparathyroidism, hypoparathyroidism, thymus deficiency, pituitary hyperfunction and hypofunction. (4) *Uncertain Ætiology*: Paget's disease, osteopetrosis, leontiasis ossea, xanthomatoses, (*a*) Gaucher's disease, (*b*) Pick-Nieman's disease, (*c*) Schüller-Christian's disease.

THE DECIDUOUS DENTITION

Dental development in man begins about the 42nd day of intra-uterine life. At birth no portion of the permanent dentition is yet calcified, except the tips of the cusps of the first permanent molar. The teeth of the deciduous dentition are usually well formed, but gross hypoplasia of the enamel is found in cases of *fœtal rickets*. In the teeth the rachitic changes are permanent, even though the corresponding changes in the bones may disappear and leave no evidence of the disease.

The times of eruption of the deciduous teeth are approximately as follows: Central incisors, 6 months; Lateral incisors, 9 months; Canines, 18–24 months; First molars, 12–15 months; and Second molars, 24–25 months.

Both eruption and shedding of the deciduous teeth vary over a wide range in children of normal health. Cases are recorded of children born with one tooth or more erupted, and injury to the mother's nipple by this cause during suckling may necessitate the provision of a suitable shield or recourse to artificial feeding.

Disorders Associated with the Deciduous Teeth.

There has been much difference of opinion as to whether teething produces the ailments commonly seen in infants at this period. Whilst "teething" is often

used by ignorant mothers to explain purely coincidental illness, it is equally true that a wide range of symptoms, owing their source to the disturbances of digestion produced by dentition, are found to resist effective treatment during the cutting of a tooth and to clear up spontaneously when the tooth has emerged and oral comfort is regained. Furthermore, Still believes that reflex nervous disturbance produced by dentition may be the actual cause of twitching, convulsions, coryza and transient bronchitis even in healthy children. While he does not agree with those who hold that it may be a cause of epilepsy, he thinks that it may aggravate this disease. It has been noticed that facial eczema is liable to exacerbation at the eruption of each tooth, and that other skin rashes are apt to appear, disappearing when the tooth is fully through the gum. The writer himself has observed the daughter of a colleague who invariably exhibited an ipsi-lateral patch of herpetic eruption on the chin during the cutting of the mandibular teeth, including also the six-year-old molar. The gums themselves, which are usually swollen and tender, are liable to sepsis if the infant tries to relieve the pain by biting dirty objects, and some authorities believe that many of the troubles of dentition could be avoided by careful oral hygiene.

The teeth most commonly causing severe symptoms are the central incisors and the molars, of which the latter are often very large teeth. In susceptible children it is common for the same prodromal symptoms to herald the eruption of a fresh tooth, and the mothers learn to recognise the signs. Although teething is a physiological event, prompt surgical intervention will often curtail a bout of unpleasant symptoms. There is certainly no dental reason, and there would appear to be no other good reason, for not lancing the gum immediately once a tooth gives premonitory signs of painful eruption. To delay in doing so is simply to prolong the child's sufferings, and to add palliatives or correctives in the form of opiates or aperients is merely making matters worse.

Lancing the Gum. The muco-periosteum in some cases is dense, and its perforation by the crown of the tooth becomes a long and tiresome process. Immediate relief is obtained by lancing the taut muco-periosteum, or preferably by removing an elliptical pad of gum from over the tooth so as to expose the crown freely. No anaesthetic is necessary. The child should be held firmly by the arms and shoulders upon the lap of the nurse in such a way that the head may rest on the surgeon's knees when he sits opposite her. In this way complete control is obtained and the incisions may be made expeditiously.

Cysts of eruption occasionally appear as bluish membranous distensions over the crowns of erupting teeth. They are, in fact, follicular cysts due to distension of the tooth follicle which has failed to rupture in order to allow egress of the tooth. Mostly they are small, but sometimes they attract attention, and when seen for the first time may be mistaken for angiomata. The contents when uninfected are a clear glary fluid. The small cysts which appear in the front of the mouth over the incisors need only be lanced. The large ones are seen over the molars and should be treated by excising a portion of the wall so as to expose the tooth freely and prevent re-healing of the wound. The tooth then erupts normally.

Partial eruption with impaction and subsequent burying of a deciduous molar, usually the second, sometimes occurs and is an exceptional cause of impaction of a permanent tooth. In these cases there appears to be a retardation or arrest of eruption at the age when the deciduous molars have barely emerged. The morsal

surface of the tooth appears through the gum but remains at that level and fails to come into occlusion with its opposing tooth (fig. 2859). The molar has in fact become impacted under the distal bulge of the anterior tooth and, while so arrested, the first permanent molar behind it has erupted and has swung forward somewhat over it. The result is that the tooth is trapped. Sometimes absorption of the roots and normal shedding of the arrested temporary molars occurs; but at other times

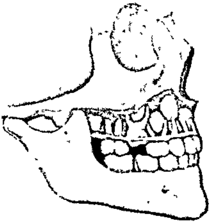


Fig. 2859.—Drawing of a case of impaction of the maxillary second deciduous molar. When unnoticed these teeth may become totally buried within the alveolar process. The permanent premolar also remains impacted against the roots of the deciduous molar.

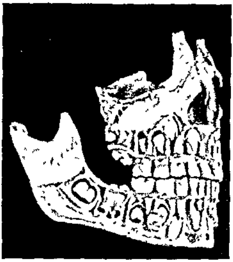


Fig. 2860.—Photograph of the skull of a child, about 6 years of age, showing the stage of development and the relative positions of the permanent teeth.

the milk molar is not shed and, remaining at its developmental level, becomes, as it were, submerged by the preponderating growth of alveolus around the permanent teeth in front and behind it. Subsequently it is found completely buried in the gum with the permanent teeth tilted together over it and its own successional tooth impacted against its roots.

Shedding of the deciduous teeth usually takes place without untoward incidents The roots of the milk teeth are absorbed *pari passu* with the eruption of their permanent successors. No pain or distress occurs, and the crown of the deciduous tooth falls out. If the shed tooth be swallowed, no untoward results ensue; but a rare, though actual, complication of grave importance arises when a loosened front tooth is inhaled. It may drop into the trachea without exciting immediate symptoms and the removal of so small and polished an object may prove extremely difficult.

THE PERMANENT DENTITION

The permanent teeth are laid down and calcified long before their eruption through the gum (fig. 2860). Defects in their formation date, therefore, from infancy and early childhood. Soft dark teeth, lacking white enamel, are hereditary in certain families.

The presence of an excessive amount of fluorine in drinking water has been shown to cause mottling, but the deciduous teeth are very rarely affected as a

result of ingestion of fluorine by the mother. The mottling, which is endemic in certain districts, appears as unsightly white, yellow or brown spots of irregular pattern on the enamel. Two other colour variations appear to be well recognised, a green colouration due to intense or prolonged jaundice in the newborn, and pink teeth in cases of congenital hæmatoporphyrinuria. Absence of vitamin D at the time of formation of the enamel is said to cause defects predisposing to caries.

Statistics of eruption of the permanent teeth in large numbers of children are now available and confirm the findings of earlier observers that dentition in general occurs rather sooner in girls than in boys, but towards adolescence the difference becomes less marked. The approximate dates for the permanent dentition are as follows: Central incisors, 7–8 years Lateral incisors, 7–8 years; Canines, 10–12 years; First premolars, 9–10 years, Second premolars, 10–11 years; First molars, 6 years; Second molars 12 years; and Third molars, 18–23 years.

Normal eruption of the permanent teeth, especially of those which replace deciduous predecessors, usually causes no distress at all, but the first and second permanent molars, having no forerunners may reproduce in a modified form the same troubles which the infant suffered when cutting the milk molars. The tooth which causes the most discomfort, however is the third molar or wisdom tooth.

Anomalies in Numbers—Supernumerary Teeth Certain teeth, like the upper lateral incisors and the upper wisdom teeth, are subject to extreme diminution in size and to congenital absence The mandibular second premolar is also often absent. Some teeth are also subject to reduplication and fully-formed fourth molars are sometimes seen. Fusion of teeth also occurs.

Supernumerary teeth appear in both dentitions and are sometimes erupted, but in the permanent series they are more often only partially erupted or completely buried While they have been found in all parts of the mouth, the common sites are in the upper jaw—the premaxilla and the third molar region, and in the mandible—near the second premolar and behind the third molar. They vary in form from large moderately well formed teeth to nests of fifteen or more tiny denticles. Mostly they are small cone-shaped pegs occurring singly or in pairs, and are often inverted They are commonly found between and behind or above the roots of the central incisors (fig. 2861), and in the cleft in cases of cleft palate. In any case of non-eruption of a permanent upper central incisor or of an upper wisdom tooth, and sometimes of a lower wisdom tooth, impaction against a supernumerary tooth may be suspected

These adventitious elements are usually free from painful symptoms and are found mainly in the course of routine examination. Occasionally, however, severe neuralgia is produced by a supernumerary denticle absorbing its way into the root of a permanent tooth and exposing the pulp (fig. 2862*a*). If all the normal teeth of the series are present and in good clinical condition, a dental cause of the pain may be unsuspected, as happened in the case illustrated, until a skiagraphic examination is made. Finally, like other buried teeth they may become infected and form the seat of toxic absorption and may also give rise to dentigerous cysts (fig. 2862*b*).

Mal-eruption and Impaction of the Permanent Teeth.

Mal-eruption or impaction of permanent teeth arises from various causes offering mechanical obstruction to normal eruption, such as supernumerary teeth

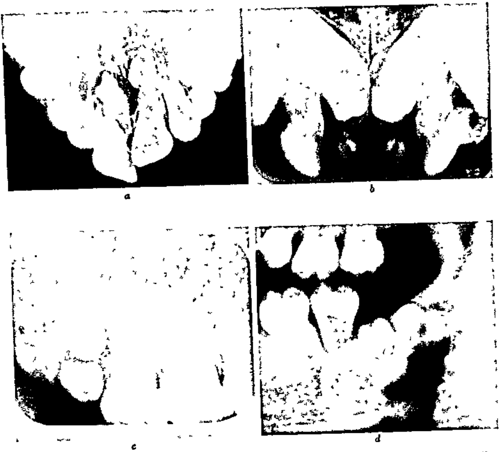


Fig 2861.—SKIAGRAMS SHOWING THE COMMON SITES AND APPEARANCE OF SUPERNUMERARY TEETH
(*a*) Supernumerary denticles in the premaxilla above and posterior to the roots of the central incisors.
(*b*) Two supernumerary denticles causing impaction and non eruption of the central incisors
(*c*) A supernumerary denticle (or paramolar) obstructing the eruption of an upper wisdom tooth.
(*d*) A supernumerary (or fourth) molar obstructing the eruption of a lower wisdom tooth

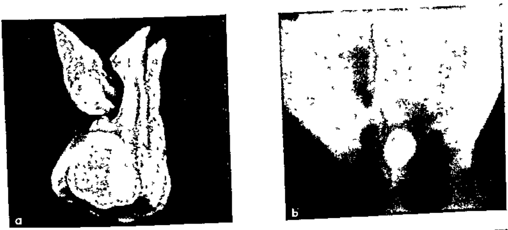


Fig 2862.—(*a*) DRAWING OF A SPECIMEN WHICH CAUSED NEURALGIA OF OBSCURE ORIGIN, ULTIMATELY TRACED TO PULPAL IRRITATION IN THE THIRD MOLAR DUE TO ITS ABSORPTION BY AN INTRUDING SUPERNUMERARY DENTICLE. (*b*) SKIAGRAM OF A FOLLICULAR CYST, A BURIED SUPERNUMERARY DENTICLE IN THE PREMAXILLA OF AN EDENTULOUS PATIENT PRESENTING A SWELLING IN THIS REGION.

and other adventitious or residual dental masses. The more common cause, however, is that of general crowding of the teeth due to insufficient room in the alveolar arches and often aggravated by the early loss of a deciduous tooth. In these circumstances the permanent tooth may become impacted against the roots of its neighbour, or become deflected and lie transversely. The teeth most commonly impacted (apart from wisdom teeth) are the canines and the second premolars, both maxillary and mandibular (fig 2863). These teeth when buried do not cause pain or discomfort. Their presence is usually unsuspected unless either a tooth is observed to be missing or a follicular (or dentigerous) cyst arises to call attention to their existence They may only be discovered accidentally later in adult life during routine X ray examination. Apart from the possibility of cyst formation, their importance lies in the danger that they will become infected and thus be changed from mere foreign bodies into fertile sources of toxæmia.

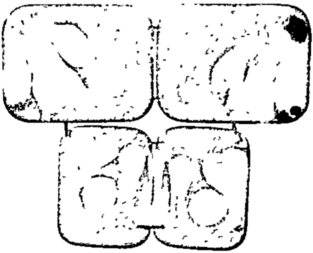


Fig 2863 — Skiagrams of buried teeth (other than wisdom teeth). Upper and lower second premolars.

In the mandible a buried tooth is a source of weakness, often determining the site and direction of traumatic fracture of the bone, and in later middle-age gross sepsis resulting in sub-acute osteomyelitis, or mild sepsis exciting a condensing proliferative osteitis, may bring the case under the surgeon's notice.

There is no doubt that buried teeth, if they cannot be brought into their proper position in the dental arch, should be removed while the patient is young and the bone is still very vascular and uninfected. To ignore them is culpable, and to leave them until the patient is older is to increase the hazards of the operation. Not only does the bone itself become harder and devascularised and both the operation and healing more difficult but, as experience shows, adult patients will only have these teeth removed as a last resort, when they have been suffering for a long time from some chronic disability which all other measures have failed to cure. These cases of long-standing infection and failing resistance are the very ones in which removal of the tooth is likely to be followed by such disasters as sub-acute bacterial endocarditis and death. The writer has recorded a case of fatal secondary osteo-

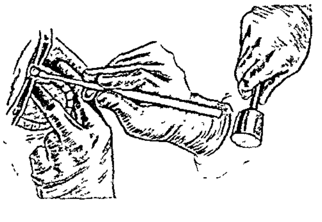
myelitis of the spinal vertebræ following the extraction of an infected buried wisdom tooth 9 months previously in a man of 55 years, and a case of fatal endocarditis consequent upon the disturbance of a similar tooth in a woman of 61 years.

OPERATIVE TREATMENT OF BURIED TEETH

The operation for the removal of buried teeth used to be an unsatisfactory process of groping and digging. It is now as deliberate and precise as any other surgical procedure. The change is due to accurate localising by stereoscopic radiography, quiet anæsthesia by the intra-tracheal or intravenous route, or by premedication and block novocaine, and the use of the aspirator to keep the field of operation in full view. No two pictures could contrast more strongly than the old hit-and-miss methods under open anæsthesia and the present accepted standards of modern oral surgery. Although the abundant blood supply of the jaws allows the operator to take liberties, and up to a certain point he need not be unduly afraid of introducing infection from the surrounding tissues of the mouth or of inflicting local crushing and bruising, there is no doubt that the wounds of all jaw *operations made in a scrupulously clean field with freshly sharpened instruments by a technique which eliminates blind digging and crushing of tissues heal more quickly and without pain or swelling.* If these precautions are carried out, together with attention to such details as flushing the subsequent cavity in the bone to remove all loose sequestra and seeing that hæmorrhage has ceased before closing the wound, it is possible to obtain healing of the incision by first intention with the result that many days of needless plugging and irrigation and a great deal of after-pain are eliminated. It is impossible to lay too much stress on these facts. Both in surgical and in nursing practice, the mere fact that the case is " dental " seems often to be sufficient reason for refusing the patient the most elementary precautions and the simplest consideration, in spite of the excruciating pain which dental irritation of the trigeminus is known to excite. In all cases, from the extraction of a single tooth to major excisions of bone, the teeth should be adequately scaled and polished *and the gum-pockets disinfected by a dental surgeon before operation. Preliminary* antiseptic mouth-washes, especially hydrogen peroxide, are useful as adjuncts but are of poor value compared with thorough mechanical cleansing.

(1) *Removal of Buried Teeth (apart from Wisdom Teeth) from the Maxilla.* Except for the third molars, teeth which have failed to erupt in the maxilla are mostly found on the palatal side of the dental arch. The patient should

Fig. 2864.—METHOD OF EXCISING BONE IN DENTAL OPERATIONS. THE SURGEON'S LEFT HAND SUPPORTS THE JAW, HIS RIGHT HAND HOLDS THE CHISEL, AND THE MALLETING IS PERFORMED BY AN ASSISTANT.



be placed recumbent, therefore, with the shoulders raised on a hard pillow and the head thrown well back, as for tonsillectomy. The surgeon will most conveniently operate from behind—i.e. over and across the patient's face and, for an expeditious

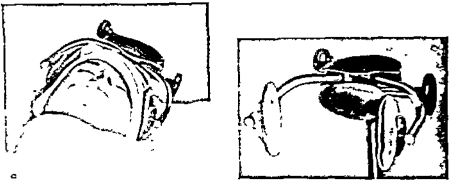


Fig. 2565.—Author's head-clamp for stabilising the head during operations upon the mouth and face.

Fig. 2566.—(a) A specimen showing typical position of a canine impacted in the palate; the bone has been partially removed. (*Museum, R.C.S.*)

(b), (c) and (d) Stages of operation for removing the tooth when full exposure is not practicable and the application of dental forceps is also prevented by the orientation of the buried tooth and the proximity of other teeth.

operation, two assistants are necessary. One of them retracts the flap and aspirates the blood from the field and the other delivers blows with a mallet upon the chisel which the surgeon holds in one hand while he steadies the jaw with the other (see fig. 2564). Some form of head-clamp should be used instead of sand-bags, which are generally unsatisfactory (fig. 2565). An incision is made in the palatal mucosa

along the margins of the teeth and should extend sufficiently far to enable the site to be freely exposed. It is a mistake to attempt to operate through a small incision. The muco-periosteum is detached and held well back, and the tooth is uncovered by chiselling away the bone. It is not usually possible to expose the whole of the tooth, and it may be difficult to prise the tooth out of the bone if its tip is locked between the teeth in front of it. In this case it is best to divide the buried tooth transversely in two places with a smart blow of the mallet on the chisel or with a dental burr so that, a section having been removed from the middle, the two extremities may be delivered through the space thus made (fig. 2866). The wound is thoroughly irrigated with saline to remove debris, bleeding is controlled, and the flap is sutured back into place. Pressure is maintained for several minutes to prevent excess of blood collecting between the flap and the surface of the bone.

(2) *Removal of Buried Teeth (apart from Wisdom Teeth) from the Mandible.* The lower canine tooth develops to the outer or labial side of the dental arcade and, when buried, is usually found in this position, whereas the second premolar is for a similar reason mostly found on the inner or lingual aspect of the adjacent teeth. The lower canine is easily removed through an appropriate incision in the reflection of the mucous membrane. The incision should be semilunar and convex upward towards, but not injuring, the gingivæ. The tooth is usually not entirely buried in the bone and its tip may often be seen when the periosteal covering is detached. The second premolar—unless it is vertically placed, in which case the bulge of its crown can generally be palpated lingually close to the floor of the mouth —is mostly buried entirely within the body of the mandible and its removal is difficult because access through the mouth is restricted. An incision should be made in the buccal sulcus and great care taken to avoid, if possible, severing the labial branches of the mandibular nerve when the soft tissues are detached from the surface of the bone. Suitable retraction is made, and the overlying bone chiselled away or burred off with a drill. The tooth is removed whole or piecemeal according to the circumstances, and the cavity and wound are treated appropriately. In exceptional

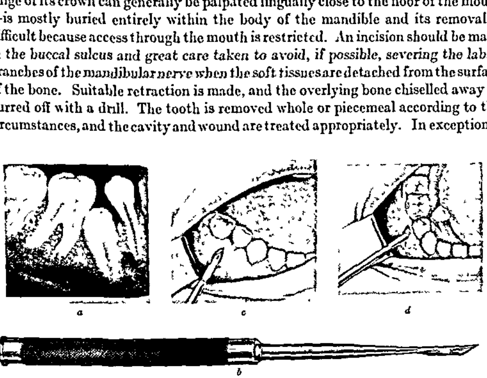


Fig. 2867.—METHOD OF REMOVING AN IN-STANDING LOWER SECOND PREMOLAR TOO DEEPLY BURIED TO APPLY DENTAL FORCEPS. (*a*) THE CROWN IS FIRST EXPOSED ON THE LINGUAL ASPECT AND A SHARPLY POINTED CHISEL (*b*) IS THEN DRIVEN INTO THE BONE ON THE BUCCAL SIDE IN A DIRECTION OBLIQUELY UPWARDS AND INWARDS. IT IMPINGES AGAINST THE ROOT (*c*) AND FORCES THE TOOTH OUT OF ITS SOCKET (*d*).

cases this tooth is situated so close to the lower border of the mandible as to make access to it more easy through an external incision.

Even when vertically placed, the buried second premolar may present difficulty in being removed without injury to the adjacent teeth, for it is often not accessible to dental forceps. The procedure in these cases is to make a preliminary vertical incision in the lingual mucosa over the crown and to remove as much of the thin overlying bone as is possible upon this aspect. A vertical incision in the muco-periosteum is now made on the buccal side over the long axis of the tooth, and a sharply-pointed instrument is driven inwards upon its root by means of a mallet until it is felt to engage the tooth, and then upwards so that the point of the instrument, impinging upon the tooth, carries it out of its socket through the lingual incision (see fig. 2867)

(3) *Conservative Operations upon Buried Teeth as an aid to Orthodontic Treatment.* In estimating the advisability of removing from a young subject a well-formed and possibly useful tooth, before ruthlessly extirpating it the surgeon is advised to consult with the dental surgeon, for it is known that, if sufficient room in the contracted arch be provided for them by orthodontic expansion and their crowns be sufficiently freed from overlying bone, teeth, even when completely buried and seemingly badly displaced, will turn and erupt in adolescents in a remarkable fashion, like the premolars shown in figures 2867*a* and *c*. Another typical case is that of a buried central incisor impacted against a supernumerary tooth. After the obstructing supernumerary has been extracted, the crown (only) of the incisor may be carefully freed from bone and the case handed over to a dental surgeon for orthodontic treatment. If this operation is performed during the period of eruptive activity, an incisor so freed will move spontaneously towards its proper position, provided that treatment by an *expansion* plate or other device is first employed to make sufficient room for it between the adjacent teeth of the gap (fig. 2868*b*). In older subjects, traction might be necessary to draw the tooth into position. After the twenty-fifth year the regenerative power of the alveolar bone around a translated tooth diminishes progressively and the possibility of infection increases, so that it is doubtful if after this age the procedure is justified.

An unexpected but common cause of deflection of the mandibular premolars is impaction against the overlying cortex of the bone when this has become condensed owing to the early loss of the deciduous predecessors through extraction necessitated by caries (fig. 2868). In these cases the bone of the deciduous sockets is apt to consolidate too heavily to allow the permanent tooth to emerge, even where there is room for it, and, following the line of least resistance, the tooth becomes directed into the medullary space and may be found lying transversely, either forwards or backwards, as shown in the illustrations. A satisfactory prophylactic operation in the adolescent is to remove the overlying bone and expose the crown. Like the upper incisor already described, the tooth, when freed, if within the eruptive period, will rotate spontaneously and erupt normally in the arch.

IMPACTED THIRD MOLARS

The wisdom teeth, being the last teeth to erupt, are necessarily the ones which are most commonly affected by under-development of the jaws or by premature arrest of normal skeletal growth. Hunter, Tomes, and more recent authorities like Brash and also Smyth and Young have shown that from birth, or shortly

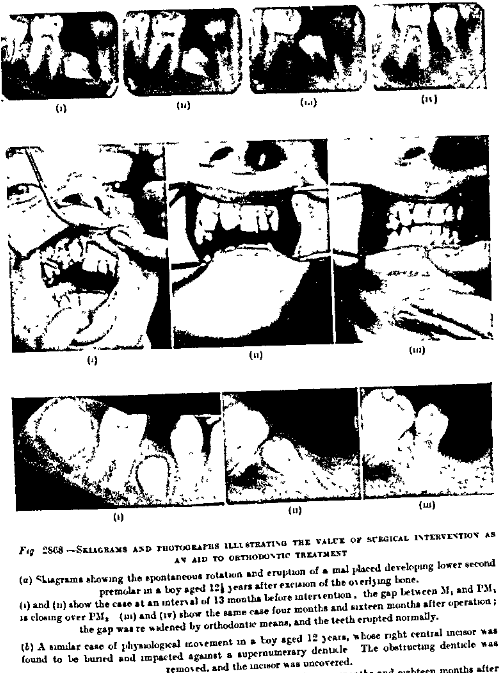


Fig 2868.—SKIAGRAMS AND PHOTOGRAPHS ILLUSTRATING THE VALUE OF SURGICAL INTERVENTION AS AN AID TO ORTHODONTIC TREATMENT

(*a*) Skiagrams showing the spontaneous rotation and eruption of a mal placed developing lower second premolar in a boy aged $12\frac{1}{2}$ years after excision of the overlying bone.

(i) and (ii) show the case at an interval of 13 months before intervention, the gap between M_1 and PM_1 is closing over PM_2. (iii) and (iv) show the same case four months and sixteen months after operation; the gap was re widened by orthodontic means, and the teeth erupted normally.

(*b*) A similar case of physiological movement in a boy aged 12 years, whose right central incisor was found to be buried and impacted against a supernumerary denticle. The obstructing denticle was removed, and the incisor was uncovered.

(i), (ii) and (iii) show the progress of physiological movement seven months and eighteen months after operation. In this case the gap was not stretched, but room was made by removing also the lateral incisor.

(*c*) Skiagrams of one side in a bilateral case of inclusion of the lower second premolar (PM_2), due to impaction against the more densely ossified cortex of the mandible, following early removal of the deciduous predecessor and of the first permanent molar (M_1).

(i) Shows the case at 9 years before the subsequent extraction M_1 necessitated by caries. PM_2 is normally placed. (ii) Shows that five years later PM_2 has failed to erupt and is seen to have become deflected posteriorly and to be impacted against M_2. (iii) Shows the same case fifteen months after excision of overlying bone. The tooth has turned and erupted normally by physiological effort unaided by mechanical traction with orthodontic appliances.

after, there is no appreciable interstitial growth of the alveolar arches for the reception of the successional teeth; there is only a lengthening posteriorly to accommodate the permanent molars, which accompanies a downward and forward growth of the lower face. Many patients show gross overcrowding and narrowness anteriorly, but posteriorly sufficient length has developed to allow complete eruption of the wisdom teeth. On the other hand, many others have a reasonably broad arch anteriorly and no excessive crowding or overlapping, but there is insufficient length at the back to receive the third molars, which remain in their developmental position or become deflected through their own eruptive activity.

The lesions associated with, or referable to, mal-erupted and buried wisdom teeth are remarkable both for their variety and their severity. In a comprehensive study the writer collected from private sources 311 case-reports of complications and accidents relating to these teeth, and set them side by side for comparison with an even number taken without selection from recent literature.

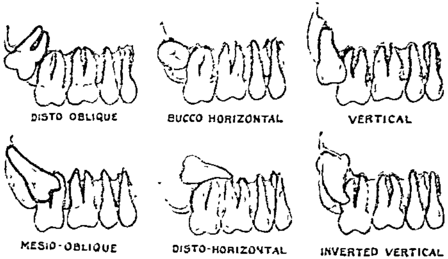


Fig. 2869.—Diagram illustrating various impactions of the upper wisdom tooth.
("*Medical Press and Circular.*")

The 622 reports were carefully analysed and the results collected into a table. The symptoms were seen to be broadly divided into: (1) those attributable to pressure of the misplaced wisdom tooth upon the tooth in front or upon adjacent nerve-endings or bundles, (2) those due to infection or to cystic distension of the follicle, and (3) those following untimely or unskilful operative interference. The remote effects were of interest, particularly where sub-liminal irritation had resulted in herpes, or in epilepsy or vaguer disturbances in mentality and disposition.

The Upper Wisdom Tooth.

The upper wisdom tooth, like all the permanent molars successively, is developed in a crypt high up in the antral wall on the posterior aspect of the maxilla. In its normal developmental attitude its occlusal surface faces directly backwards and somewhat outwards. When its eruption is prevented, it is commonly found, fully-developed, in this attitude; but it may, and often does, assume a variety of positions (fig. 2869). Sometimes it is found directed obliquely forwards, its crown

impinging upon and absorbing its way into the roots of the second molar. This is a cause of severe neuralgia of obscure origin (fig. 2870). At other times it may be found directed horizontally outwards, its roots in contact with or embraced by those of the adjacent molar with which it may in fact be fused (fig. 2871). Again, it may be found inverted, its crown pointing upwards towards the floor of the orbit. Lastly, it may be found bulging into the antral sinus ; and, if it becomes infected, it may be responsible for chronic sepsis of this cavity.

For the most part the unerupted upper wisdom tooth does not cause symptoms, one reason being that it does not suffer from the condition of partial eruption which makes the lower wisdom tooth such a fruitful source of severe and sometimes grave illness. The upper wisdom tooth is usually either fully erupted or completely buried. Nevertheless, some distressing lesions and fatal infections have been recorded. Moreover, like all other buried teeth, unerupted upper wisdom

a *b*

Fig. 2870.—(*a*) Skiagram of an upper wisdom tooth impacted against the second molar, absorbing its way into the latter, and causing severe neuralgia. (*b*) Drawing of the two teeth when removed.

c

Fig 2871.—A buried upper wisdom tooth, its roots embraced by and fused with those of the second molar.

teeth are susceptible to follicular distension, and the cyst so formed may occlude the greater portion of the antrum before it is discovered.

Removal of a buried upper wisdom tooth is most easily accomplished through an oblique incision in the buccal sulcus above and behind the roots of the second molar. The mouth should be maintained as closed as possible to avoid the interference which is otherwise caused by the ascending ramus when the mouth is gagged open. The covering of bone is removed from the outer aspect of the maxillary tuberosity and posterior antral wall sufficiently to allow a curved pointed instrument or a thin periosteal elevator to be inserted between the crown of the wisdom tooth and the socket of the adjacent tooth. The attachment of the upper wisdom tooth is usually trivial and the bone is sufficiently thin to offer little resistance once an instrument has been inserted. The risk is that the tooth may be pushed out of its socket and be lost in the soft tissue of the spheno-maxillary fossa. During the process of removal, once it is loose, the tooth should be kept under control until it is ultimately delivered through the orifice of the wound. The incision need not be sutured, as it heals readily by first intention. When acute suppuration is present, drainage is essential, but in these cases the risk of spreading the sepsis further afield should preclude any attempts to extract

the tooth. The pus only should be evacuated and the tooth left for subsequent removal when quiescence has been restored.

The Lower Wisdom Tooth.

Owing to the difficulty which the lower third molar has in erupting to its proper place in the dental arcade, it usually causes more trouble to its possessor than all the other teeth in the mouth put together. A study of developmental

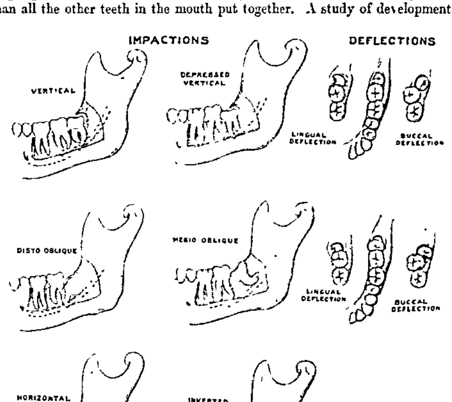


Fig 2872.—Diagrammatic scheme of the main types of impaction of the third mandibular molar, showing the relation of this tooth to the second molar, to the coronoid process and to the mandibular canal. The tooth is not always situated directly behind the second molar, but as well as being impacted and rotated in an antero-posterior direction it may also be deflected towards the tongue or towards the cheek.

("*Medical Press and Circular*")

series of human and anthropoid jaws has shown that phylogenetically this molar appears with its biting surface directed lingually. This stage is not a normal one in human ontogeny, but cases of lingual deflection are sometimes met with, apparently as an atavistic variation Like all the permanent molars, the wisdom teeth develop both phylogenetically and ontogenetically with their occlusal surfaces tilted considerably forward. If, therefore, owing to failure of growth of the mandible there is insufficient room for this developing tooth to rotate to the vertical position, then it is likely to be found pointing forward towards the second

molar, *mesio-oblique impaction*, or even lying quite horizontally facing forwards, *horizontal impaction*. Growth of the jaws in man appears to be independent of, and not proportionate to, the size of the teeth, and molar crowding occurs because the lack of forward development of the snout has not been accompanied by a proportionate diminution in the antero-posterior diameters of the teeth. Crowding naturally affects most the tooth which comes last through the gum—i.e. the third molar (fig. 2872). Sometimes development is so deficient that both the second and third molars become mutually impacted and buried (fig. 2873).

In other cases the tooth succeeds in finding room for its rotation to the vertical position but is unable to obtain sufficient room for the whole of its antero-posterior diameter between the second molar and the ascending ramus of the mandible. In these cases the condition of *vertical* or *coronoid impaction* is found, the tooth being perfectly placed but more or less of its occlusal surface lying within the

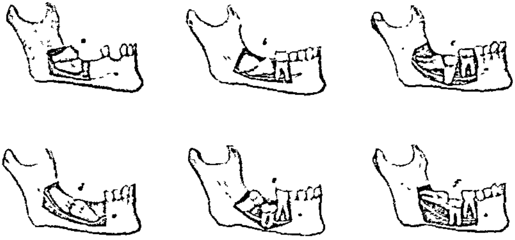


Fig. 2873.—Drawings made from skiagrams showing double impaction of both the second and third mandibular molars. The second molar is primarily impacted, and deflection of the third molar ensues. Proximity of the mandibular nerve, which may be seen in three cases *to lie in a foramen* through the roots of the second molar, usually gives rise to paroxysmal neuralgia which brings the cases under observation.

coronoid process. A variant of this form of impaction is seen when the tooth manages to clear the anterior edge of the bone, but does not succeed in emerging fully from the fold of mucous membrane which covers the anterior border of the coronoid. This is sometimes described as "*soft-tissue impaction.*" The posterior cusps lie hidden under the fold which forms a hood, appropriately termed by French writers the *capuchon*. Underneath this hood is an ideal nidus for bacterial growth. The space is approached from the mouth along the occlusal surface, but is very badly drained. Here organisms collect, setting up a variety of septic troubles, many of which may come to the general surgeon before their dental origin is realised.

The lower wisdom tooth, however, is not always tucked in behind the second molar. It may be far removed from its normal site, and the fact that it does not appear in a given set of dental films does not necessarily mean that it is congenitally absent. Cases are seen where the tooth is situated either close to the sigmoid notch or displaced to the lower border near the angle. These teeth mostly attract attention by producing swelling of the cheek owing to cystic distension or sepsis

of their follicles, and the lesions may be mistaken for pathological conditions of the parotid gland. One remarkable case in which the wisdom tooth was overlooked in this way occurred in a case of intractable and almost fatal asthma, from which the patient recovered when the peccant tooth had been discovered and removed. Although it is possible to reach some of these deeply placed teeth by the oral route, drainage is more effectively established and the removal more easily and expeditiously accomplished by a suitable external incision which must, of course, be planned to avoid branches of the facial nerve. In rare instances the mandibular wisdom tooth may erupt with its crown directed horizontally, through the external plate of the mandible and eventually, through suppuration in its follicle, perforate the skin of the face

OPERATIVE TREATMENT OF IMPACTED LOWER THIRD MOLAR TEETH

(1) *During Acute Infection*

The third molar should never be extracted when sepsis is fulminating under the *capuchon* It is highly dangerous to open up a raw area at a time when such

Fig 2874.—THE STAGES OF INFECTION OF THE CRYPT OR FOLLICLE OF AN ERUPTING THIRD MOLAR. (*a*) THE THIRD MOLAR IS UNERUPTED AND TOTALLY ENCLOSED. (*b*) THE ANTERIOR CUSPS HAVE EMERGED THROUGH THE GUM WHICH LINGERS OVER THE BITING SURFACE. INGRESS OF INFECTION TAKES PLACE UNDER THIS HOOD OR "CAPUCHON" AND GAINS ACCESS TO THE FOLLICULAR SPACE POSTERIORLY TO THE CROWN. (*c*) INFLAMMATORY REACTION CAUSES SWELLING AND TURGIDITY OF THE "CAPUCHON," WHICH IS AGGRAVATED BY BEING BITTEN UPON BY THE CUSPS OF THE UPPER MOLAR TOOTH. (*d*) FURTHER SWELLING CONSTRICTS THE ORIFICE OF THE HOOD UPON THE CROWN OF THE LOWER MOLAR SO THAT DRAINAGE FROM THE FOLLICLE IS OBSTRUCTED; AN ABSCESS FORMS, AND THE SEPSIS MAY SPREAD DEEPLY IN THE SURROUNDING TISSUES.

("*Medical Press and Circular*")

an infection is stronger than the patient's local resistance, especially when the manipulations necessary to remove the tooth include the cutting of bone and the crushing or laceration of soft tissues. A number of fatal cases have been recorded on this account The condition must be treated symptomatically by poulticing, by local antiseptic applications and syringing under the hood, and by lancing the hood and, if necessary, the cheek to establish drainage. It is commonly found that the pain is greatly increased by the *upper* wisdom tooth impinging upon the inflamed *capuchon* (fig. 2874). It is good practice then to remove the upper tooth at once, for great relief is thereby given and its extraction is simple if trismus and tumefaction are not too great. When the sepsis has subsided the lower tooth should be extracted to prevent the almost inevitable recurrence

(2) *Extraction of the Impacted Tooth.*

This is a major operation and must be conducted in a surgically-clean field, preferably by an operator who has special skill. Sharp cutting instruments must

be used and all bruising and crushing must be avoided. Most cases of post-operative pain, swelling and trismus are due to the trauma of a clumsy operation and to *inattention to pre-operative sanitation of the denture and lack of operative asepsis.*

There are several methods of effecting delivery of the impacted wisdom tooth from the confined region in which it is situated, and all surgeons who are accustomed to deal with these cases have their own particular modifications in technique

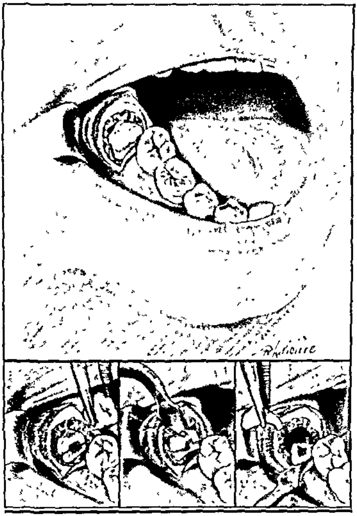


Fig 2875.—Stages of operation for removal of a buried wisdom tooth with divergent fangs by the process of "splitting," so as to avoid injury to the mandibular canal and nerve.

and their individual patterns of instruments. The operation is not always a difficult one, but it is commonly made so by the absence of proper diagnostic skiagrams—*taken stereoscopically and in several directions if need be*—and by the surgeon's unfamiliarity with the mechanics of delivery in a given case, which only a study of the formation, shape and direction of the roots and a precise knowledge of their local anatomy can correct. Winter has shown that each type of impaction has characteristic features, and that the most expeditious method of removing an impacted tooth is only to be learnt by a *detailed study of dry specimens, so that the surgeon may know* where bone is most profitably removed and in which direction, and how, according to the attitude of the tooth

and the shape and direction of its roots, elevation from its socket is most easily achieved. Given this precise knowledge, much fruitless chiselling and prising is eliminated. Some surgeons remove a large amount of bone from the buccal and posterior aspects in order to allow an easy passage for the whole tooth, and some advocate excising the lingual plate. The writer prefers mostly to take away a modicum of bone and to extract the tooth, in several pieces if necessary, after cleaving it with a chisel or severing it with a burr run in a dental engine. Cleaving a molar is a knack: the surgeon directs the chisel whilst he steadies the jaw with his other hand, and a crisp tap is given to its butt by a practised assistant. The crown is severed transversely in most cases and the roots are then divided and drawn into the space provided (see fig. 2575). The socket is flushed with saline to remove all debris. The preference for this method of operation lies in the fact that it is peculiarly non-traumatic and swifter than grinding the tooth with a dental engine, besides being more convenient. Chisels are light to transport, easily sterilised, and delicate to control. A dental engine is the reverse. However, discrimination is necessary; all cases are not suitable for this technique of cleaving, especially where the jaw itself, as in old people, is likely to be fragile.

In clean cases healing is expedited by suturing the flaps. The more septic cases benefit by light plugging with gauze soaked in acriflavine-paraffin emulsion. When marked sclerosis is present, as in some patients over middle age, the risk of sub-acute osteomyelitis and pathological fracture should be remembered. These cases are better treated by plugging the orifice, for several weeks if necessary, until healthy granulations sufficiently fill up from the bottom.

(3) *Post-Operative Sequelæ of Impacted Lower Wisdom Teeth.*

The operative accident and the post-operative complication are perhaps more likely to come under the general surgeon's care than the actual removal of the average impacted lower wisdom tooth. In the 622 cases analysed there were 23 cases of traumatic fracture of the jaw during attempts to remove the tooth. There were 11 cases of pathological fracture following osteomyelitis of the socket

Fig. 2576.—Case of fatal thrombophlebitis of the cavernous sinus following acute suppuration of a lower molar. (*From the Kieferstation University Clinic of Vienna, by courtesy of Prof. H. Pichler.*)

after extraction. There were 8 cases where the tooth was lost in the soft tissues after being dislodged from the socket; with one exception, where displacement took place to the outer side, the track was on the inner side in the lax tissue deep to the anterior pillar. When the extraction had been conducted under nitrous oxide anæsthesia, movements of deglutition tended to carry the tooth further from its socket. If the case is seen early it may be possible to retrieve the tooth through the original opening; otherwise an incision in the floor of the mouth or in the fauces becomes necessary. One lower third molar lost in this way was indeed exfoliated from the tonsil six months later. Other post-operative complications are spreading cellulitis of the neck, leading to œdema of the glottis, Ludwig's angina, and mediastinal abscess. Sometimes the spread is upwards, and thrombophlebitis of the cavernous sinus occurs (fig. 2876). In the analysed cases death occurred in forty-two, of which one was due to secondary osteomyelitis of the spine and another to primary epithelioma of the socket.

It is evident that a large proportion of the severely septic complications in these cases arose through the operator, in his anxiety to appease a suffering patient, unwisely attempting to remove a third molar which subsequently proved more difficult than he had anticipated. The necessity in these acute cases for preliminary symptomatic treatment—lancing to establish efficient drainage and so forth—cannot be too strongly stressed. The tooth may be removed later, when the fulminating condition has subsided.

There is also a type of lesion of the impacted lower wisdom tooth which is apt to be followed by the most serious fulmination; this occurs when inexpert attempts to extract the tooth, or destruction by caries, have caused putrescence of the pulp and the apex has become infected. The gravity of this condition is that the apex of the lower third molar is often situated below the level of the attachment of the mylo-hyoid ridge and is barely covered by the inner cortical plate. Sepsis breaks easily through this thin barrier and tracks directly into the deeper fascial planes. If, however, the cortex of the mandible over the apex is thick and discharge of pus does not take place readily up the side of the tooth, acute osteomyelitis may easily supervene. The symptoms of apical abscess closely resemble those of follicular suppuration when both conditions are seen in a late stage, and differentiation between them is of diagnostic importance: whilst it is right to treat acute sepsis of the follicle by lancing and other symptomatic measures in order to gain quiescence before extracting the tooth, in these cases of severe apical suppuration it is urgent to remove the tooth with the minimum delay. In the first instance, for reasons already given, it is desirable to postpone extraction until the acute symptoms have subsided; but in the second instance, the infective agent is the tooth itself which also acts as a plug against the discharge of pus from within the interior of the bone. A skiagram which may be expected to confirm the diagnosis is essential. Owing to the socket being dependent, drainage is difficult but may be facilitated by excising the lingual plate. Counter-drainage below the angle of the jaw should be quickly established if the infection shows signs of spreading beyond control (see fig. 2876).

Injury to the Mandibular and Lingual Nerves.

The proximity of the mandibular canal and its contained neuro-vascular bundle commands consideration if the patient is to be spared unnecessary after-pain or the possibility of permanent numbness of the same side of the lower lip.

Many cases are on record where the roots of the third molar had developed so as partially or entirely to embrace this canal, and the extracted tooth has accordingly shown a groove or a foramen. If the latter, rupture of the nerve was inevitable when the tooth was extracted; in cases where the root is grooved only, delicate handling may preserve the nerve from injury. When a third molar is obliquely impacted and has to be forced backwards after it has been uncovered in order to disengage it from the posterior aspect of the molar in front of it, there is grave risk not only of crushing the nerve and so producing temporary numbness of the lip, but also of admitting infection from the socket into the mandibular canal through a breach in the wall and thus initiating a septic neuritis. Much of the severe pain following otherwise successful operations upon the lower wisdom tooth appears to be due to this cause, aggravated by inattention to proper pre-operative preparation. The method of severing the tooth and withdrawing its component parts would appear to offer more protection to this structure than endeavouring to remove the tooth whole. The lingual branch of the third division usually escapes injury, but in some cases when the jaw is short and the buried third molar is consequently placed relatively far back or deeply, or when excision of the lingual plate is not carefully performed, the nerve may be cut and hemi-anæsthesia of the tongue result.

With the exception of hæmorrhage, the remaining post-operative complications are due solely to inexpertness or injudicious force on the part of the operator. These include breaking the third molar and leaving behind fragments, with consequent pain and suppuration later on; breaking the crown of the second molar when leverage has been used against it and exposing its "pulp"; and breaking an instrument, such as a chisel or elevator, and leaving the fragment wedged in the bone, or a hypodermic needle when regional novocaine has been used. As previously mentioned, mandibles have been broken and dislocated. Wisdom teeth have been dislodged from their sockets and pushed into the soft tissues on the inner or the outer face of the mandible, and in this connection it should be remembered that the apex of a broken third molar tooth may be pushed easily through the internal plate when this is thin, and disappear into the lax tissue with unpleasant sequelæ. It must be admitted, however, that, common as these accidents are, they are all avoidable and would not occur if the cases were regarded as major operations and conducted under the same conditions of anæsthesia, visibility of field, and deliberateness of attack as any other operation.

(4) *Prophylactic (Surgical) Treatment of Impaction of Lower Wisdom Teeth.*

The danger to life, health and comfort of an impacted wisdom tooth is so great that it should, when possible, be removed before it is completely formed, at a time when the operation is simple and safe. Other prophylactic measures, such as extraction of an anterior tooth, will often enable a third molar to come into good position in a crowded mouth and are advocated when it is not possible to take out the wisdom tooth itself; but sometimes the tooth is so badly placed that it has no chance at all of erupting normally. Since there is a definite mortality associated with these impactions, every child ought to be radiographed between the ages of seven to ten and at yearly intervals afterwards in order to watch the development of the third molars. The occlusal surface appears to form on an average between the ages of seven and eight and it seems reasonably possible at this time to forecast the probability of impaction. If it is proposed to remove the wisdom tooth,

operation should not be delayed later than the early stage of calcification. At this period the tooth germ lies in a crypt, which is open on the surface of the bone (fig. 2877) and is easily enucleated. It is convenient to operate under intratracheal anæsthesia and, as absolute asepsis is imperative, patients should be warded.

Author's Operation.

With the mouth open and suitable retractors in place, the vestibulum of the cheek is stretched so as to bring the ascending ramus into prominence. To effect this a rounded retractor (such as a Frankel tongue depressor) or the forefinger is pushed backwards along the buccal sulcus in the mouth to the outer side of the ascending ramus. A vertical, slightly curved incision is then made, beginning in front at the posterior limit of the tight pad of gum which overlies the second molar and extending for ¾-inch upwards. The convexity of the curve should be towards

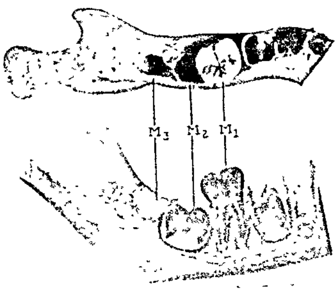


Fig. 2877.—Mandible of a child aged 8 years, showing the open crypt of the developing wisdom tooth at this age and the ease of access to the follicle.

the mid-line of the mouth The incision is made deeply to the bone and passes through fibres of the temporal muscle, sometimes severing a nutrient vessel. The orifice of the third molar crypt is seen at once, and the bone is bared with a narrow raspatory over an area of ½-inch square. The sides of the wound are held open with retractors (Austin pattern) and the crypt is opened. In young patients the roof is never complete and is as thin as egg-shell, so that it can very easily be removed by hand pressure or, more neatly, by light blows on a ½-inch mastoid chisel with a mallet. Four strokes usually suffice to lift off a square from the roof of the crypt and give ready access (see fig. 2878). An important point to remember, however, is that rapidity of operation depends on getting the calcified mass out easily. The novice is apt to operate through too small an opening. If the cusps only are calcified, a sharp spoon readily crushes the occlusal surface; but if the whole occlusal surface of the crown is calcified, it will not break and the orifice in the bone must be larger accordingly. The advantage of operating soon after the beginning of calcification is obvious. In the early stage the crypt is distended almost to its full size, but the calcified mass is still small. There is, therefore, plenty of room between it and the crypt wall for inserting instruments. Later,

from the age of twelve onwards, the calcified crown fills the whole of the crypt and its manipulation becomes progressively more difficult.

When the overhang of the roof has been removed as far as is necessary, a flat sharp spoon is passed down the side of the crypt and its contents are enucleated. Usually the follicle breaks and the first object to be delivered is a square, firm pale pink disc—the dentine papilla—which squeezes out. Further curettage either breaks up the calcified mass, which then comes away piecemeal, or delivers

Fig. 2878.—The stages of the author's operation for enucleation of the follicle of the developing wisdom tooth in children at the age of 8 to 10 years.

(a) The incision on the ascending ramus.
(b) The sac of the follicle bulging through the patent roof of the bony crypt.
(c) Enlargement of the aperture.
(d) Enucleation of the follicle sac and its contents.

it whole. The connective tissue of the follicle separates easily from the bony wall and is removed. The field is kept dry with a suitable aspirator and finally, in case any calcific material and bone debris are left behind, the crypt is flushed with saline. Formerly I used to suture the wound, but a tendency in some cases to bleed into the tissues and cause swelling of the cheek has led me to leave these cases unsutured and to apply pads of cotton wool on the face under a tight bandage. Any seepage of blood comes out through the wound which invariably heals by first intention. Provided the case is handled with aseptic precaution there is no need to introduce antiseptics or plugging.

Advantages. The operation is quickly and easily performed. Although the tidying up, if scrupulously done, may take several minutes, the actual removal of the tooth germ should not exceed a minute, and the procedure contrasts, therefore, most favourably with the difficulty of extracting the *same* tooth *when the whole* crown is formed, and still more when it is deeply buried or horizontally placed with divergent curving roots. The trauma is less and the patient benefits by losing the

Fig. 2879.—Skiagrams showing (*a*) a suitable case for enucleation of the third molar germs in a child of 9½ years. (*b*) The same case twenty-two months after operation, showing ossification of the crypt and continued normal eruption of the second molar. ("*Lancet.*")

tooth before infection has crept in, at a time also when the bone is soft and healing is rapid. Instead of a socket which may take six weeks to heal and give trouble and inconvenience meanwhile, the incision of this operation heals by first intention and the crypt is quickly obliterated. There is no disability and the patients are allowed up on the following day. I have now completed seventy cases with no untoward results and without an anxious moment (fig. 2879).

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Fig. 2678.—THE STAGES OF THE AUTHOR'S OPERATION FOR ENUCLEATION OF THE FOLLICLE OF THE DEVELOPING WISDOM TOOTH IN CHILDREN AT THE AGE OF 8 TO 10 YEARS.

(*a*) The incision on the ascending ramus.

(*b*) The sac of the follicle bulging through the patent roof of the bony crypt.

(*c*) Enlargement of the aperture.

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CHAPTER II

Injuries and Diseases of the Teeth

INJURIES OF THE TEETH

Traumatic violence, whether directly applied to the teeth themselves or due to a blow on the jaw or to the jar of a fall, may result in concussion, fracture, or dislocation of one or more teeth. In *concussion* the tooth is driven into its socket, the periodontal membrane is crushed and inflammation may be initiated in the pulp. Teeth which are damaged by forcibly opening the jaws with a gag or by the patient's biting upon something hard often show concussion. If the tooth remains alive it is tender to bite upon, owing to chronic periodontitis, and it may be unduly sensitive to heat and cold. The symptoms often persist indefinitely and extraction may be ultimately necessary for relief. A form of dental cyst sometimes found in the lower incisor region is initiated by a blow and is termed by some writers "traumatic cyst." Injury to the vascular supply or inflammation of the pulp, however, more commonly happens. Degeneration sets in and the tooth, whilst it may recover from the initial concussion, loses its translucency and ultimately turns dark. The pulp should be removed before it becomes septic and apical infection supervenes, or the tooth should be extracted.

Fracture of the tooth, although seen in adults in severe accidents, most usually occurs in children whilst romping or playing games, especially if the central incisors are prominent. Sometimes the tooth is broken transversely across the crown but more commonly a corner is broken off. Provided the pulp is not injured and degeneration due to the concussion does not set in, the tooth may be preserved and ultimately restored with an inlay or a porcelain jacket-crown. If the pulp is exposed, its repair is improbable and it should be extirpated and the root canal filled. If, however, radiographs show the apex of the root to be still patent, filling the canal cannot be successful and the tooth must be extracted. The apex closes about two years after eruption of the crown. The gap left by an upper incisor tooth so extracted in children should be maintained by a suitable dental appliance until an artificial tooth can be fitted; otherwise it partially closes with unsightly consequences. Aseptic fracture of a tooth deep in the socket is also known, and regeneration of dental repair tissue and healing sometimes occur. Teeth fractured in this way need not be extracted without first giving them a chance of recovery by immobilising them with a cast metal splint.

Dislocation of a tooth from its socket may be partial or complete. When the dislocation is *partial*, the tooth and the supporting alveolus should be pressed back into position and rest procured either by ligaturing with silk or wire or, better, by cementing upon it and the neighbouring teeth a cast metal splint, which can be made rapidly from a plaster model. The splint should remain in place for a month or six weeks. When it is removed, the tooth should be tested for vitality and treated accordingly. *Complete* dislocation occurs more commonly in the

playing field or in an automobile accident, and cases are known where the tooth has been recovered, washed in mild antiseptic lotion, and reinserted in the socket. Healing has taken place and these teeth have lasted as long as twenty years. Vitality of the pulp is said sometimes to be re-established, but the chances are unlikely, and since the risk of inoculation with tetanus or other gravely pathogenic organisms is always present, it seems wiser to effect a proper sterilisation of the tooth and to fill its pulp canal before replanting it. In all these cases, however, the undesirability of retaining a dead tooth should be given consideration.

A type of semi-dislocation of developing teeth in their crypts is found to occur during operations upon the infantile jaws. Sometimes the teeth are pushed inwards upon the soft and yielding dentine papilla, and unless the crown recovers its position it forms a dwarfed deformed tooth which fails to erupt or may become an odontome. Similarly, by the rough extraction of the deciduous teeth, sharp twists and bends may be caused in the permanent teeth which interfere subsequently with their proper eruption. Cases are on record also in which a molar has been badly displaced from its normal site by traumatic interference with its germ or follicle during an operation for sequestrectomy following osteomyelitis of the mandible.

Attrition and Abrasion

Of the "natural" injuries to the teeth which are responsible for pathological changes, attrition and abrasion may be mentioned. Attrition is the wearing down of the teeth by the effect of mastication, especially in races where the diet is coarse. It is rarely seen in the more effete communities. In its grosser degree, as seen in aboriginal and archaic skulls, the teeth, especially the molars, have been worn down more rapidly than the dental pulps could lay down secondary dentine as a protection. The pulps have become exposed and infected and dento-alveolar abscesses like those produced by caries, have formed. Similarly, excessive abrasion due to a gritty dentifrice may destroy the labial surfaces of the teeth. Once the hard protective layer of enamel is worn through, the destruction is rapid and exposure of the pulp with abscess formation may occur unless a protective layer of secondary dentine is laid down sufficiently quickly. In civilised races gross destruction by either attrition or abrasion is rarely seen; but cases have been seen in which injudicious gripping upon the stem of a tobacco pipe or the excessive use of a tooth-brush in a faulty direction has become responsible for the death and infection of a tooth and this has given rise to severe secondary infection elsewhere in the host.

CARIES

Ætiology and Predisposing Effects of Uncleanliness in the Mouth.

While in certain subjects over middle age low grade infection of the jaws may be associated with a clean set of teeth, it is certain that oral uncleanliness is always associated with disease of the teeth and gums. Indeed it might be said that, in spite of a variety of other causes and predisposing factors presenting complicated biochemical problems, in the majority of people health of the teeth and gums is directly proportional to the degree of perfection attained in oral hygiene. Whenever food stagnates in the mouth, pabulum is provided for bacterial growth, and invasion of the subjacent tissue—be it tooth or gingival crevice—results. A number of factors determine whether the damage done by the stagnation is to the enamel of the tooth, leading to caries, or to the tissues around the tooth,

producing periodontitis or paradontosis. Often both are present. For example, a child who, having had previously entirely clean teeth, goes away to school and neglects to clean them properly, shows in a few weeks the traces of his neglect. He acquires a lodgment of glutinous starchy debris in the gingival crevices of the unbrushed teeth and extending on to the surface of the enamel and into the inter-dental clefts. At first no damage is apparent, but continued stagnation with the inevitable fermentation and putrefaction leads to carious decalcification of the enamel and to chronic infection of the gum margin, which is seen to be infected and swollen. When the debris is cleaned away, the enamel underneath appears as an opaque white patch which later on either progresses to a carious cavity or remains as a disfiguring brown mark.

Dental caries, as such, does not greatly concern the general surgeon ; but the effects of decay may have both a causative and an aggravating relation to lesions in other parts of the body. The causation of caries is not fully understood ; some important work has recently been done indicating that if the enamel is properly laid down at the time of formation of the tooth no amount of subsequent insult to its surface will set up decay. The laying down of enamel, as of other calcareous tissues, appears to be dependent on the proper functioning of the parathyroid glands, an adequate supply of vitamin D, and a sufficiency of calcium and phosphorus in the blood at the material time. It is held that if adequate supplies of vitamin D are provided for the pregnant woman (when the temporary teeth are being formed) and for the infant and young child, the enamel will be properly laid down and decay prevented. It is even maintained that the incidence of caries can be reduced in adult life if there is plenty of vitamin D in the diet. This question is still *sub judice*, as is also that of the protective value of adsorption from the saliva which, it has been suggested, hardens the teeth or in some other way makes them less liable to decay.

From the practical point of view in general surgery, however, the fact remains that stagnation of food on the teeth inevitably leads to caries. Apart from the places of contact by artificial appliances, the common sites for food stagnation are around the necks of the teeth at the junction with the gums, in the inter-dental spaces and in the deep crevices and pits of the occlusal surfaces—and these are the points of incipient decay. " Prophylactic odontotomy " is a term which has been used to describe the drilling-out and filling of these deep fissures and pits before decay has set in and this, along with the institution of a proper method of cleaning, is a valuable measure in preventive dentistry. From these small carious patches, if neglected, springs the ultimate menace of the dead tooth. Any artificial appliance, from a partial denture to an artificial obturator, which depends for its stability upon contact with the teeth is a predisposing cause. Appliances of this kind as well as the natural teeth supporting them should be brushed regularly after food, and the inter-dental spaces cleaned with dental tape. The artificial contrivance should, if possible, be left out of the mouth for half an hour or so after meals to permit the solution of residual debris by the salivary currents.

Mouth-breathing, by interfering with the normal washing of the teeth and gums by the saliva, is a potent cause of dental disease. The child with a short upper lip and a habit of nocturnal mouth-breathing commonly exhibits decay in the front teeth and gingivitis of the segment of the gums so exposed. The habit appears to

Pulpitis and Dento-alveolar Abscess.

When caries reaches the pulp, or when the pulp is otherwise injured by trauma, an inflammatory reaction takes place and leads to self-strangulation of the vascular supply. When the reaction is acute, pulpitis gives rise to the familiar symptoms of raging toothache of the sharp lancinating type and spreading to the whole distribution of the trigeminal nerve. Immediate relief is given by extraction, or by release of intra-dental pressure by removing with a dental excavator the covering of decayed dentine so as to expose the pulp cavity. Anodynes, such as oil of cloves and carbol-eugenol, are of no use in these acute conditions. They are only suitable to cover an exposed but quiescent pulp which requires temporary protection from external stimuli.

Instead of acute inflammation of the pulp, especially under a filling, there may be a sub-acute decomposition giving rise to intermittent bouts of severe odontalgia which are usually initiated by eating or drinking too hot or too cold food. The bouts tend to become more severe, more widespread and more frequent, and the patient avoids taking anything into the mouth that is not at body heat. If the tooth is not extracted or cleaned out and rendered sanitary, infection from the putrescent pulp passes through the apex into the alveolar bone

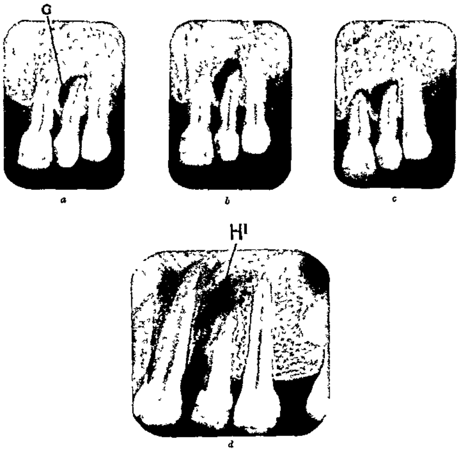

Fig. 2880.—Skiadrams of a lateral incisor showing (*a*) a clearly defined area of apical rarefaction indicating a long standing chronic abcess with good resistance, (*b*) and (*c*) enlargement and spread of the area due to failing resistance, and (*d*) skiagram of a hazy area of apical rarefaction, H[1] indicating a granuloma and poor resistance.

("*Lancet.*")

of the socket. Here again the reaction may be acute or chronic. Before suppuration occurs in the bone there is a stage of periodontitis. Swelling of the periodontal membrane lifts the tooth out of its socket slightly above its neighbours so that it meets the opposite jaw first. It is a little loose and very tender to pressure. It does not react to thermal changes although heat may increase slightly a residual pulpitis.

Eventually the sepsis spreads to the bone, either as an acute fulminating abscess with the classical signs and symptoms, or as an insidious painless chronic infection not giving rise to any symptoms and only discoverable skiagraphically. In young people, the tendency is towards the formation of the familiar chronic abscess which, as a little yellow pus-containing sac, often comes away adhering to the fang of the tooth. In older people, the tendency is rather towards the formation of a granuloma which is apparently due to, and indicative of, a less effective response. Clinical dental experience also seems to confirm that a tooth which shows on the skiagram with a clearly defined walled-in area (see fig. 2880*a*, *b* and *c*) usually contains an abscess sac and is less harmful than one showing an area with a hazy ill-defined outline which is characteristic of the granuloma (see fig. 2880*d*). An abscess sac once formed tends to remain the same size until specific resistance breaks down entirely (see fig. 2880*b* and *c*). A granuloma, if anything, tends towards gradual enlargement. From a surgical point of view the sac of the chronic abscess being of fibrous tissue, is usually strong enough to come away with the tooth. The granuloma, on the other hand, is friable and, if at all large, tears from the apex of the tooth and is left behind. Patients having granulomata are mostly in a state of chronic lowered resistance and have insufficient reaction to eradicate the infective mass which may persist after the infection as an area of residual focal infection. When such a tooth is extracted, the apex of the socket should be opened up and curetted to remove the granulomatous material.

Treatment of Acute Dento-alveolar Abscess

As already indicated, there is a fundamental difference between the pathology of acute dento-alveolar abscess of apical origin and the peri-coronal abscess of an impacted lower wisdom tooth due to infection under the *capuchon*, and treatment should be modified accordingly. In the wisdom tooth the sepsis is in the follicle around the crown, and during the fulminating stage a simple incision to establish drainage is preferable to removing the tooth, an operation which is often extremely difficult and traumatic. In the case of a dento-alveolar abscess the sepsis is beyond the apex of the tooth, the putrescent pulp of which is the origin of the trouble. The tooth is usually found to be loose in its socket through softening of its attachments, and its extraction is mostly a simple matter and may be effected quickly and with absence of trauma. In cases of acute apical abscess the most effective treatment is immediate extraction of the tooth.

Sometimes removal of the tooth does not establish sufficient drainage and a supplementary incision in the buccal sulcus of the gum, or in the case of lower teeth even externally on the cheek or neck, becomes necessary. In this event care should be taken to avoid important structures such as branches of the facial nerve, and the incision should as far as possible be made in the direction of the platysmal fibres and placed so as not to be unsightly. But the tooth must not be left. To incise the abscess externally and leave the tooth gives rise to a chronically

discharging sinus with considerable cicatrisation and dimpling of the scar due to its adherence to the bone.

Treatment of Chronic Apical Abscess and Granuloma—Apicectomy.

The treatment of granuloma and chronic abscess of the dental apex is necessarily radical if it is to conform with the accepted standards of modern surgery. There is obviously everything to be gained by the early and complete elimination of infection from the bone around the apex of the affected tooth before the infection has become established in sclerotic loculi and while the patient's resistance is still sufficiently good to eradicate the residuum. No treatment of the tooth short of its complete removal can, as yet, guarantee its successful sterilisation and that of the surrounding bone. In all cases, therefore, *immediate extraction is advocated.*

Conservative treatment, while not advisable, is sometimes demanded by the patient for a conspicuous front tooth and in certain circumstances the operation of *apicectomy* may be expedient. The first step is the sterilisation of the interior

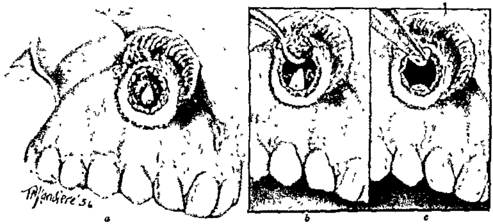

Fig. 2881.—Apicectomy. Stages of operation.
(*a*) Muco-periosteal flap turned up and root apex exposed.
(*b*) Clearance of peri apical cavity
(*c*) Excision of projecting apex.

of the pulp-chamber, which is ultimately filled with non-irritating antiseptic root-canal filling which must occlude the spaces within the tooth and be tolerated by the soft tissues of the socket into which the apical foramina lead. The interior of the tooth may be sterilised by chemical antiseptics, by ionisation or by diathermy, and the pulp canal should not be filled permanently until a sterile paper point, sealed and left in the canal for forty-eight hours, is shown to produce no growth upon culturing. Subsequent radiographs commonly show osteogenesis and obliteration of the rarefied apical area after successful treatment upon these lines, and surgical intervention may in fact become unnecessary. Ultra-violet radiation with the Kromayer lamp appears to be a valuable adjuvant.

If, however, the area is encysted and cannot be obliterated by this preliminary treatment apicectomy must be performed (fig. 2881). After the tooth has been treated and filled, a semilunar incision is made in the buccal mucosa. The flap of muco-periosteum is detached and retracted, and with a small chisel the alveolar bone over the rarefied area is removed. The apex of the root which is thus exposed is found projecting into the cavity and is excised by a sharp blow

with a suitably small chisel, or is cut off with a dental drill. It is then smoothed level with the floor of the cavity by means of burrs or small carborundum stones. The granulomatous mass or abscess sac is curetted and flushed out of the cavity along with debris from the tooth. Finally, the bony wall is scraped to freshen it, and the flap is drawn down over the orifice and pressed into place. One or two fine sutures may be inserted if desired but are usually unnecessary.

The results of this operation, as indeed are those of simple but effective antiseptic treatment of the tooth alone, appear to be encouraging, but not enough bacteriological and histo-pathological research has yet been done to justify regarding it as more than a palliative. For further information upon the preservation of dead teeth the reader is referred to the dental literature and to the histological studies of Gottlieb of Vienna and his co-workers. The danger of dead teeth, already stressed by Rosenow and many others, need not be emphasised.

EXTRACTION OF THE TEETH

In the past twenty years there has been a change in policy and in technique relating to the extraction of teeth. With the advent of quiet anaesthesia—either conductive, intra-tracheal, or intravenous—the need for hasty "drawing" of an infected tooth or for the clearance of a mouth full of septic teeth under a single administration of nitrous oxide after the face-piece has been withdrawn (i.e. during the recovery period) has gone. Furthermore, with greater knowledge of focal infection of dental origin and the increasing use of radiography, certain important factors hitherto unappreciated have come to the fore. Excluding extraction of a tooth for the relief of pain due to pulpitis, the removal of a septic tooth is necessitated by the fact that the infection, whether it be apical or gingival in origin, ultimately enters the bone around the root. In these circumstances the tooth resembles a foreign body and, if a portion of the fang be left behind, a nucleus for infection remains and the operation has failed to achieve its full purpose. In all classes of patients teeth may be seen with long, thin, brittle roots, or curved roots, or with cemental thickening, so-called exostosis, of the roots, producing knob-like swellings of the apical third. These teeth are of the kind most likely to be broken. Also, in the private patient more particularly, and increasingly in the hospital patient, the process of conserving devitalised teeth for aesthetic and masticating purposes has produced a new clinical entity: a condensing and often a proliferative osteitis in the bone accompanied by an increased brittleness in the tooth, the roots of which when devitalised may have been still further weakened by having been reamed out during the process of filling. Unless these teeth have straight conical roots, they are difficult and often impossible to remove by ordinary methods with dental forceps. The buried fragments of root left after incomplete extraction are invariably infected. Thus it has become no longer a question of the nimble extraction of the major portion of the tooth, leaving the apex, if broken, to remain or to be exfoliated in due course, but rather of the complete removal of the whole tooth, piecemeal if necessary, by a deliberate [illegible] over, increasing use of radiography has shown that the mere [illegible] tooth is not always sufficient to enable the bone to recover from the [illegible] times the infection is localised in an abscess sac at the apex [illegible] mass either at the apex or in the side wall of the socket, [illegible] y be discovered. At other times the septic process takes

the form of a more diffuse softening of the medullary tissue—a species of carious osteitis (fig. 2882). In all these conditions, when the tooth has been extracted to prevent a persistence of residual infection, it is desirable to open the alveolar socket and enucleate the abscess sac, granuloma or cyst, as the case may be, or to curette away the carious infected bone, taking suitable precautions.

Experience of the application of surgical principles to dentistry shows that, provided the field is made as clean as is mechanically and antiseptically possible by the removal of accumulations of tartar and the use of a pre-operative mouth-wash, and provided that neat cutting with freshly sharpened instruments takes the place of wrenching and crushing of the bone with forceps, difficult teeth may be extracted without either after-pain or general reaction to the sepsis liberated into the blood stream. Consequently, to meet modern conditions there has been a change in the dental armamentarium. The numerous patterns of special forceps of complicated design fitting their respective teeth are reduced to two or three and simplified, but the list is augmented by a scalpel and periosteal elevator, a

Fig 2882.—Skiagram of diffuse osteitis spreading from a dead and septic upper molar. Extraction of the tooth should be accompanied by curettage of the carious alveolar bone ("*Lancet*")

retractor, a mallet and mastoid chisel, two pairs of pointed elevators, some suitably shaped curettes, tissue forceps, and sutures. With these instruments it is possible to extract any tooth, including buried ones.

Extraction of Teeth.

The left hand should grasp firmly between the fingers and thumb the portion of the jaw over the root of the tooth to be extracted. The beaks of the forceps, which should be sharp, should be driven upwards or downwards as the case may be, between the root of the tooth and the alveolar bone, as far as it is possible to force them. This manœuvre secures a firm grip upon the tooth and reduces the likelihood of breaking it. With the forceps held firmly in position the next step is to enlarge the socket by forcing the tooth back and forth alternately inwards and outwards until it is felt to "give." For most teeth a firm inward movement followed by a "wheeling" outward movement suffices to extract them. The roots of the upper central incisors and the lower first premolars are mostly conical, straight, and circular in transverse section. In the case of these teeth the inward movement may be accompanied by lateral rotation so that the tooth is twisted round in its socket. When the attachments of the tooth have been broken by this means, traction easily delivers it. Care should always be taken to see that a portion of the gum is not adhering to the tooth, otherwise when this is dragged upon, an unpleasant tear of the mucous membrane may be caused which is likely to be painful afterwards. An intimate knowledge of the conformation of the roots of the teeth is obviously an advantage, for then the beaks of the forceps can be applied more suitably and the force used more critically. In the case of lower molars, especially the first molars which are two-rooted, the beaks of the forceps

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the form of a more diffuse softening of the medullary tissue—a species of carious osteitis (fig. 2882). In all these conditions, when the tooth has been extracted to prevent a persistence of residual infection, it is desirable to open the alveolar socket and enucleate the abscess sac, granuloma or cyst, as the case may be, or to curette away the carious infected bone, taking suitable precautions.

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should be placed upon the stronger root of the two, usually the anterior one. Sometimes the second root will also come away with the crown, but at other times the posterior root will be left behind and must be removed separately, either with forceps or with a suitable elevator passed down the empty socket of the extracted root.

In the case of the upper molar teeth, which are normally three-rooted—two slender external or buccal fangs and one strong palatal fang—the forceps should be set upon the palatal root and the anterior buccal root. If the posterior buccal root is left behind, it may be retrieved by passing a blade of the forceps up the empty socket of the palatal root whilst the external blade is set upon the outer side of the remaining root. Sometimes an upper molar tooth has very widely curving fangs, and to remove the tooth as a whole would entail a great loss of alveolar structure. In these cases a satisfactory method is to excise the crown and separate the individual roots so that they may be removed one at a time. This is done by means of suitably shaped cleaving forceps or by placing the edge of a chisel against the buccal side of the tooth, horizontally at the gum level below the edge of the enamel, and giving it a smart tap, which easily cleaves the crown from the roots. The chisel is then placed axially and the buccal roots are similarly separated by vertical cleavage from the palatal roots. The two buccal roots are then separated from one another in the same way. Each root, being free to move independently of its companions, is then extracted with forceps in the direction of its long axis or is prised out by means of a pointed elevator.

Successful healing of extraction wounds has been shown to depend upon the formation and rapid organisation of a sound, clean clot in the socket. When the clot is healthy, epithelialisation of the surface of the clot at the contracted orifice of the socket occurs in eight days, and organisation progresses by the intrusion of blood-vessels from the socket wall as well as from the gum margin. In those cases, however, in which sclerosis of the alveolar bone has occurred owing to long-standing low-grade infection, the socket wall is devascularised and the clot, failing to become organised, disintegrates through *septic infection. The condition, which* is known as "dry socket," is more prone to occur in the mandible and, since the lower sockets are undraining, more pain is experienced than in the maxilla by the septic accumulations in the depth of the socket irritating local nerve-endings. On inspection, the socket is seen to contain the residuum of decomposed greenish clot and when this is irrigated away, the socket wall appears bare and dirty white. The treatment is to wash the socket daily by syringing with a copious mild lotion, such as hydrogen peroxide, 2 vols., and to pack it with a crushed tablet of aspirin. The analgesic effect of the aspirin relieves the neuralgia and it does not interfere with the formation of repair tissue. Healing is necessarily slow.

The following are the common accidents and sequelæ of dental extractions: Emphysema; breakage of the tooth or of the instrument with loss in the soft tissues of the fragment; dislodgment and loss of the tooth either in the soft tissues or in the antrum or down the œsophagus or trachea; hæmorrhage from the socket; fracture of the jaw; dislocation of the mandible; injury to the mandibular or lingual nerves, osteitis and osteomyelitis; and spreading cellulitis and thrombophlebitis.

Alveolectomy.

The method of open operation, in which the outer plate of the alveolus is

partially removed in order to facilitate the egress of the tooth, is now used in varying degrees: for the removal of a difficult tooth, to admit instrumentation to the apex of the socket for the enucleation of a granuloma or a small cyst, to enable the surgeon to remove broken pieces of alveolar bone which would otherwise form irritating sequestra, and to smooth off sharp projecting corners of the socket which form troublesome promontories under an artificial denture.

The stages for the removal of a single tooth with an apical granuloma by this method are shown in the figure (fig. 2883). An L-shaped *incision of adequate dimensions is made in the outer alveolar muco-periosteum, care being taken not to* injure the gingival margin of the adjacent teeth. A flap is raised and retracted and the *outer alveolar plate is excised with a chisel and mallet to about two-thirds* of the length of the root. The tooth is then extracted with forceps or dislodged from its socket by a pointed elevator. The granulomatous mass, if any, is

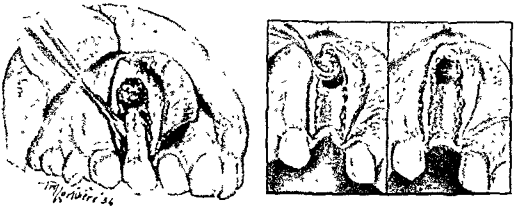
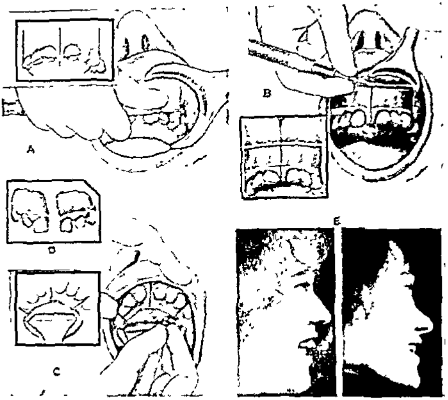


Fig. 2883.—Stages of open operation, or alveolectomy, for the removal of an upper canine tooth and enucleation of an apical granuloma. The outer plate of bone is first removed with a chisel.

enucleated with a curette and, after the bone-debris and sharp corners have been removed, the *mucosa is closed with a suture so as to restore the contour of the* gingival margins.

Removal of the outer alveolar plate *in the way described has the advantage,* when a *total clearance* of the teeth is being made, of allowing that portion of the socket which undergoes resorption to be removed at the time of the operation. Resorption of the alveolus of the sockets prevents the *permanent fitting of a* denture because the tissue base is constantly changing its shape and, for this reason, any denture made within the first six months after extraction does not preserve its initial fit. By extending the operation of *alveolectomy* it is possible to trim the bone and suture the gum in such a way as to imitate the state of the ridges after five to six months' shrinkage, but great care should be taken not to overdo the operation. Dentures, which may then be supplied immediately after operation, may be expected to retain a good fit. In this operation, four vertical incisions are made: one over the last molar and one over the canine upon each side. The inter-dental papillæ are cut through by a horizontal movement and the muco-periosteum is turned back in three large flaps

Most edentulous mouths are *fortunately* within what may be described as a "normal" range and can be fitted with a denture which is reasonably comfortable and efficient. There are, however, abnormal anatomical conditions which are



A. Vertical cuts (shown in inset) are made through the muco-periosteum and into alveolar bone by means of a fine circular saw.
B. The muco-periosteal flaps are retracted and a transverse channel above the apices of the teeth is made with a fissure burr.
C. A similar channel is made deeply in the palate.
D. The segments of alveolus with their contained teeth are removed and the bone is smoothed and the mucosal flaps sutured back.
E. Photographs of the patient from whom the segments were removed before and after treatment.
F. Photograph taken five days after operation of another patient treated similarly, showing healing by first intention.

Fig. 2884.—Stages of operation of extensive alveolectomy for the removal of an unduly prominent premaxilla in preparing the mouth for artificial dentures.

beyond the mechanical skill of the dentist, and surgical intervention is necessary to ensure ultimate comfort of the artificial denture. The developmental abnormalities include over-prominent, exostosed or hypertrophied alveolar ridges which reduce the inter-maxillary space and cause bulging so that an artificial denture cannot properly be made. Another is taurus palatinus which causes no trouble until an upper plate has to be worn. Bony projections may also be seen on the lingual aspect of the lower jaw or on the tuberosity of the hard palate. Obstructions of this kind are eliminated by removing the prominence by rongeurs or chisels, smoothing the surface, and replacing the soft tissues with sutures. Cases of extreme protrusion of the premaxilla and of large exostoses of the alveolar bone are peculiarly suitable for extensive alveolectomy, not only for æsthetic reasons but also to enable a satisfactory denture to be supplied. Figure 2884 shows a case treated in this way. The mucosa and alveolus were cut through by a very thin circular saw. The muco-periosteum was then raised and, suitable calculations having been previously made, the teeth were removed in blocks of three along with the supporting alveolus, the bone was smoothed, and the mucosal flaps were trimmed and sutured.

Frenoplasty and Frenectomy.

Sometimes the frenum of the upper lip is of exaggerated size and is attached to the central papilla of the premaxilla. In these circumstances the central incisor teeth are kept widely separated. The abnormality is partly of æsthetic importance,

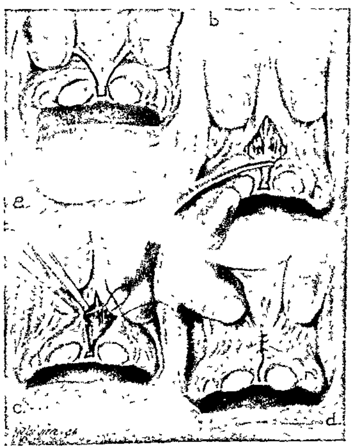


Fig. 2885.—Stages of operation for detachment of a low frenum labii drawn from photographs.

(a) A V shaped incision is made on each side of the frenum and passes deeply between the incisor teeth.

(b) The lip is forcibly drawn upwards and the sides of the muco-periosteum are raised from the bone.

(c) and (d) The diamond-shaped wound is sutured transversely.

for widely separated teeth are unsightly, but it becomes of practical importance in older patients who, having lost their teeth, require to be fitted with artificial dentures. The loose fold of mucous membrane passing directly from the alveolar ridge to the lip, like other folds occasionally found elsewhere in the mouth, prevents the proper adaptation of the plate and renders the denture unstable. The stages of operation (see fig. 2585) are given for the frenum, but other folds should be treated similarly: the important rule being so to devise the incision as to leave no raw surface to undergo cicatrisation. Orthodontic correction of the gap between the separated central incisors fails in the presence of a low frenum and, when the operation is performed for this purpose, it is important to excise as well the tough pad of springy fibrous tissue which is situated in the suture between the sockets of the two teeth.

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CHAPTER III

Diseases of the Gums and Periodontal Membrane

The Principal Causes of Inflammation of the Mucous Membrane of the Mouth are ; (1) *Mechanical Irritation* : Mal-occlusion ; artificial dentures ; food stagnation . eruption of teeth. (2) *Minerals and Drugs* : Mercury ; lead ; arsenic ; copper ; bismuth ; silver ; gold ; phosphorus ; the barbiturate and salicylate groups. (3) *General Systemic Disturbances* : Uræmia ; diabetes ; gout ; sprue ; arthritis. (4) *Physiological and Dietetic Disturbances* : Errors of diet ; menstruation , pregnancy ; avitaminosis ; scurvy ; beriberi ; pellagra. (5) *Infectious Diseases* : Measles ; diphtheria ; scarlet fever ; typhoid fever ; chicken-pox ; small-pox , tuberculosis ; syphilis ; gonorrhœa ; actinomycosis ; anthrax ; glanders ; foot and mouth disease ; pneumonia ; leprosy ; yaws (6) *Blood Diseases* : Anæmias , leukæmias ; hæmophylia. (7) *Skin Diseases* : Urticaria ; eczema ; tinea ; scleroderma ; pemphigus ; erysipelas ; lichen planus ; erythema multiforme ; erythema nodosum ; herpes zoster ; lupus vulgaris ; lupus erythematosis , purpura ; epidermolysis bullosa. (8) *Endocrine Dysfunction* : Parathyroid, thyroid—cretinism, myxœdema ; pancreas—diabetes ; pituitary.

Diseases of the Dental Supporting Tissues.

For practical purposes diseases of the supporting tissues of the teeth may be divided into :

(1) Tumours of the gums and alveolar integuments.
(2) Primary inflammatory reactions and/or degenerative changes when the *fons et origo mali* is located in the teeth and adnexa.
(3) Secondary inflammatory reactions and/or degenerative changes when the oral lesion is secondary to, or associated with, some general disease or toxic state.

Primary and secondary reactions cannot be entirely differentiated from one another. To a large extent the two conditions are interdependent, at least so far as concerns the severity of the oral lesion. As an example, local uncleanliness in the mouth provokes or admits a more severe and widespread ulceration in cases of Vincent's infection than is seen in a clean mouth and, on the other hand, certain blood dyscrasias more readily permit the invasion of the gingival and paradontal tissues by organisms which in normal circumstances in the same mouth would be regarded as saprophytic. The stomatitis of mercury or of pregnancy is not seen in the perfectly clean mouth, and the conditions in which disease in the gums and sockets of the teeth can be designated as purely secondary are comparatively few. Recognition of this interdependence is of importance to successful treatment of infections of the gingival and paradontal tissues, especially the low-grade chronic ones, and it is obvious that success is best assured by eliminating simultaneously both the local and general ætiological factors. The teeth themselves may be

regarded as masticatory implements planted in the jaws for utility, but the tissues which support them (including the dental pulp) are integral parts of the body proper and subject to exactly similar reactions, which are merely complicated, mechanically more than biologically, by the presence of the teeth.

While it is not possible entirely to differentiate between them, it is convenient to classify these various manifestations of disease in the supporting tissues of the teeth according as they affect mainly :

(1) the general mucosal lining of the buccal cavity—*stomatitis ;*
(2) the gums proper—*gingivitis* ,
(3) the periodontal membrane and alveolar bone—*paradontosis.*

STOMATITIS

Stomatitis, or inflammation of the soft tissues of the mouth, may be of varying degrees of severity and due to a great variety of causes. It has been usual to divide the degrees of inflammation into catarrhal, aphthous, ulcerative, and gangrenous, but a more logical classification based upon pathological grounds would be (1) Primary, sub-divided into non specific and specific infections, and (2) Secondary.

(1) *Primary non specific stomatitis* includes most of those conditions described as "catarrhal" In this condition the mucous membrane of the cheeks, tongue and gums appears red and swollen. The inflammation usually begins in a number of discrete patches which subsequently coalesce. There is an excessive production of sticky mucous, the epithelium becomes white and sodden, and the superficial cells are rubbed off, with resulting erosion or ulceration. The inflammation may be initiated by mechanical irritation, such as jagged teeth, or by the presence of chemicals such as too strong an antiseptic. It occurs without apparent cause but is certainly increased, if it is not actually produced, by excessive smoking It may also be found during the course of the infectious fevers and during the debility which follows them Sometimes it is associated with disturbances of the gastro-intestinal tract, such as improper feeding or dyspepsia. The *treatment consists in allaying the local irritation* and removing the cause or causes. Mild antiseptic mouth-washes are helpful and such preparations as potassium permanganate, glyco-thymoline, hydrogen peroxide, potassium chlorate, and myrrh may be used The alimentary tract must receive attention.

Primary specific stomatitis is seen in certain well-recognised infections, such as thrush, tubercle, syphilis, gonorrhœa, Vincent's infection, etc.

(2) *Secondary or associated stomatitis* is seen in conditions in which the oral mucosa exhibits its own symptoms of reaction, like the Koplik spots in measles and the snail-track ulcers of syphilis, or where, associated with a more prominent gingivitis, it is due to resistance being undermined by other intercurrent disease.

GINGIVITIS

Gingivitis is essentially a disease of the firm muco-periosteal layer which festoons the margins of the teeth. The peculiar relation of the structure, namely, that of a vascular tissue lying in contact with the inert food-collecting walls of the teeth, with an intervening catch-pit in the form of a sulcus (the gingival trough) of varying depth and degrees of drainage, is the fundamental ætiological factor which predisposes the gingivæ to pathological changes. Toxins and direct bacterial invasion from putrefying food in this sulcus initiate disease in otherwise normal

gums and still more in gums whose resistance is undermined by general disease or toxic states or, by providing a locus of diminished resistance, they facilitate the ingress of stray infections which otherwise might not have gained an entrance. The marginal gingivitis of food stagnation is an example of the first, the gingivitis of diabetes or of mercurial poisoning are examples of the second, and the invasion by Vincent's infection, which is rarely seen in a clean mouth, typifies the third.

There is no clear line of division between the gingivæ and the periodontal membranes of the teeth and, whilst it is convenient to describe separately the features of disorders more clearly seen in the gums, it must be borne in mind that extension of infection by lymphatics from the gums deeply through the periodontal membranes to the apices of the teeth, and even in the dental *pulps as well as further afield, is actively taking place in all infections of the gum margin. MacGregor, confirming the work of previous observers, has also shown the generous lymphatic drainage and the abundant anastomosis of the lymphatic vessels leading from the gingivæ. The integrity of the protective epithelium* may be disturbed by injury, toxins, lack of vitamins, and systemic disease, and, according to the predisposing factors and the nature of the infection, the resulting gingivitis may be primary or secondary and non-specific or specific.

Primary non-specific gingivitis is seen typically in mouth-breathing children or in subjects who, although nasal breathers, have so short a lip as to leave the gum uncovered. In these conditions there is an absence of natural cleaning and flushing of the gingival crevice by the salivary currents. Consequently food-debris and mucin collect there and bacterial invasion of the gingival margin results. Intercellular œdema and cellular infiltration occur, the gums become swollen and patulous and, being intensely hyperæmic, bleed upon slight digital pressure. The condition is painless and chronic, and in the averagely clean mouth *remains confined to and sharply defined in the affected region with no tendency to spread laterally. Extension of the disease to the periodontal membrane readily occurs, however, and persistence of the inflammatory reaction leads to permanent fibrotic thickening of the gum margin and inter-dental papillæ.* An accumulation of sub-gingival calculus becomes deposited below the gum level and adds to the irritation. In very dirty mouths the gingivitis extends all round the denture and is not confined to the anterior teeth.

Treatment in the early stages is simple and consists in eliminating the predisposing causes, viz. efficient scaling of the teeth, greater attention to oral hygiene, and the restitution of nasal breathing with, if necessary, suitable orthodontic regulation of the teeth to correct any deformity, such as superior protrusion, which may prevent the lips from meeting when at rest. In adult patients, too old for orthodontic treatment, in whom the premaxilla protrudes beyond the lip level, valuable assistance may be gained by providing an *oral screen*, which consists of a thin metal plate, such as is used for the palate of an artificial denture but made to fit the front surfaces of the upper and lower teeth when normally closed. The screen is worn at night by being placed in position under the lips in front of the teeth. The appliance is also useful in children, and in some cases, as well as occluding the aperture between the relaxed lips, it may be contrived so as to exert, by pressure of the lips themselves, sufficient force to push the projecting teeth into correct alignment. Ultra-violet irradiation, both locally and generally, and an adequate vitamin-containing diet are useful adjuvants. Astringents, like

tannic acid, should not be used, for they only mask the signs by reducing the hyperæmia, with the result that deep infection of the periodontal membrane and ultimately the formation of pyorrhœa pockets can occur without the patient's knowledge until a paradontal abscess develops, when it may be too late to save the tooth. Gingivectomy is also contra-indicated in the early stages, for, if it is performed whilst the predisposing factors are present, the condition of swelling and hyperæmia merely recurs immediately the gums have healed; whereas efficient treatment upon the lines previously suggested brings about such a rapid resolution that surgical interference usually becomes unnecessary. Gingivectomy is, however, very useful in correcting the residual fibrotic hypertrophy which is found in older cases of long standing, when the ætiological factors have been removed and the gums have otherwise gained normality. The operation is described on page 5221.

Primary specific gingivitis occurs as an extension from the adjacent oral mucosa in all those diseases the characteristics of which have already been mentioned, such as tubercle, syphilis, etc., but certain other states in which the infection arises in the gingivæ and tends to remain in this locality, extending laterally from tooth to tooth rather than spreading over the buccal mucosa, are recognised. The most typical is fuso-spirillary gingivitis, or trench mouth, due to infection by Vincent's organisms.

Fuso-spirillary gingivitis (Vincent) or ulcerative gingivitis, which is due to the symbiosis of Vincent's spirillum and bacillus fusiformis, is the commonest specific gingivitis. It is characterised by extreme persistence in a sub-acute or chronic form after an acute attack; remote secondary lesions; extremely insidious onset; and a predisposition to intermittent fulmination in the mouth and throat. It is undoubtedly on the increase, particularly among the middle and upper classes. A feature which must never be forgotten is the fact that, owing to the insidious onset and persistence in mild form, patients become carriers and may infect many victims without realising that they have any serious disease in the mouth.

Signs and Symptoms. In the acute condition the patient complains of acute soreness of the gums and considerable malaise. Marginal ulceration may festoon the teeth and typical fœtor is present in the breath. In the sub-acute stage the gums are swollen and purplish-red at the gingival margins and show a strong tendency to bleed spontaneously or on light pressure. There is no pain or undue tenderness. Not infrequently the patient wakes up to find a blood-stained discharge on the pillow. The characteristic fœtor in this stage may not be perceptible in more fastidious patients. In the chronic stage the gums are shrunken but normal in colour. Extensive pockets are found round the grossly affected teeth, which bleed easily on the introduction of a blunt seeker. Sometimes a symptomless bleeding from the gums is the only sign of the chronic stage. Inter-dental filth and stagnation predispose to chronicity of the disease, which in this stage is never seen in the edentulous mouth nor in those patients with averagely clean mouths where effectual toilet has been instituted.

Diagnosis. The diagnosis in all cases depends on the appearance of the characteristic spirillum and bacillus in smears from the affected areas. In the acute stage the two organisms are roughly equal in numbers, but in the more chronic stages the fusiform bacilli become relatively less numerous and secondary septic organisms begin to appear.

Treatment. Acute stage. The diagnosis having been confirmed by smears and a differential blood count made, the patient must be isolated in a nursing home. *This is essential, so that saliva-bearing articles can be effectively controlled and treatment maintained without interruption.* The surgeon and all his assistants must wear gloves, gowns and masks. The ulcers should first of all be very lightly scraped and cleared of the pseudo-membrane by delicate but copious syringing with hydrogen peroxide or, better still, normal saline administered by a de Vilbiss spray connected through a reducing valve to a cylinder of oxygen. This should remove all debris and leave a bleeding surface which is painted with pure carbolic acid. Thereafter during the daytime the patient washes his mouth every half-hour with a solution of 1 drachm of sodium perborate to a tumbler of warm water. After meals the mouth, and especially the inter-dental spaces, should be sprayed to remove food-debris. By these means the acute symptoms should be rapidly reduced and the ulcers become clean and fibrin-covered in twenty-four hours.

The essence of the treatment is the maintenance of an oxygen atmosphere in a mouth from which the slough protecting the organisms has been removed. Arsenical preparations applied locally may accelerate resolution by attacking the treponemata; Bowman's mixture of vin. ipecac. 4 dr., glycerinum 1 dr., liq. arsenic. (Fowler) ad 1 oz., may be used for this purpose. After the first twenty-four hours the gums are no longer tender, and gross tartar should be removed to facilitate flushing of the inter-dental spaces and gingival troughs. As the healed surface hardens, scaling progresses, and the patient carries out an appropriate toilet with inter-dental tape and a soft tooth-brush sterilised in spirit.

It is a great mistake to think that the infection has been banished at this stage. Smears must be examined from pyorrhœa pockets, from the margins of leaking or ill-fitting crowns and fillings, from around dead roots, from the gingival trough of partly erupted and misplaced wisdom teeth, and from the tonsillar crypts. It is very unusual not to get a positive result from these places, and further treatment is necessary. *The patient must be taught to co-operate* in securing extreme oral cleanliness by meticulously cleansing the gingival sulcus around each and every tooth by tooth-brush, dental tape, and spray. All old amalgam fillings should be removed and carious holes cleaned, the cavities being filled with fresh cement. Fixed bridges and ill-fitting shell crowns should be taken off and all sub-gingival tartar carefully removed. Persistent mouth-breathing must be counteracted.

Intra-tracheal anæsthesia is now given, the dead teeth are removed, and the periodontal pockets are excised to their full depth and curetted. Then an electro-cautery point is passed into the gingival sulcus around every single tooth and the resulting coagulum is scraped and irrigated away. Wisdom teeth which are not perfectly erupted should be removed, as they are a very common source of recurrence. The whole denture should be cauterised at one session, not piecemeal. By these means alone can complete cleansing be ensured and a clean granulating surface left. *Any attempt to save the patient or the surgeon trouble or expense defeats its own ends.*

During healing, which takes place rapidly and without discomfort, mouth-washes of hot sodium perborate solution and frequent irrigations with hydrogen peroxide are maintained. Searching bacteriological examinations must be performed, and the smears should show only a few cocci and pus cells. Any per-

sistent focus of Vincent's organisms must be treated again under novocaine. Should the tonsils still harbour the organisms, they must be enucleated when the mouth has has healed and before it becomes re-infected from them. Intravenous arsenical preparations help to arrest widespread ulceration of the cheek and throat but do not reach the gingival form, because the organisms lodge in the dental crevices and in necrotic tissue out of reach of the circulation.

Vincent's infection of the gums is a treatable disease, but half-measures are useless.

Secondary non-specific gingivitis is seen in a number of general disturbances in which the major fault lies in an impoverished state of the gingival tissues, which renders them more easily invaded by pathogenic bacteria. The condition is invariably aggravated by oral uncleanliness. Marginal gingivitis is not uncommon in the later months of pregnancy, and in quite clean mouths in some patients the gums have a hyperæmic softened texture which resolves when pregnancy is terminated. Avitaminosis, scurvy, beriberi, pellagra, endocrine dysfunction, debilitating diseases, blood disorders, and metallic and other poisons act similarly. In all these cases it is found that local uncleanliness is the exciting and aggravating factor, for it must be remembered that edentulous patients show no prominent changes in the gums. For example, when lead is taken in excess, soluble salts of the metal are deposited at the gum margin. If there is sepsis in the gingival troughs, sulphuretted hydrogen is formed, and this acts on these deposits to form lead sulphide which appears as a narrow blue or slate-coloured line round the teeth. In the absence of teeth no blue line is formed. When, therefore, the gingivitis is secondary to some general cause, the general condition must be treated by appropriate means, and local dental treatment should be directed to promoting an extreme degree of mechanical cleanliness. In extreme degrees of gingivitis secondary to the conditions mentioned in which acute ulceration occurs, the invading organisms appear to be invariably those of Vincent and they are therefore dealt with in the section on specific gingivitis.

Secondary specific gingivitis occurs when the gingival tissues have had their resistance so diminished by intercurrent disease, cellular poisons such as metals and drugs, lack of vitamins or by blood disorders as to become a ready host to the Vincent's organisms. The group therefore includes many ulcerative conditions such as those described as mercurial stomatitis, bismuth stomatitis, scurvy of the gums, etc. Although there may be characteristic differences in appearance of the gums due to the different ætiological factors, the pathology is similar in all of them and the bacteriology is identical. As in all other cases of persisting gingivitis, the pericdontal membranes and the bone of the socket soon become involved, destruction occurs, and the teeth loosen and fall out.

Treatment should be local upon the lines already advised, as well as general. A characteristic feature of Vincent's infection is the fact that it does not stimulate a leucocytic response, and in old-standing cases of the sub-acute type there is often considerable leucopenia, sometimes verging upon actual agranulocytosis. In these cases the administration of pentose nucleotide is often extremely helpful.

PERIODONTITIS AND PARADONTOSIS

Formerly the term "periodontitis" was applied also to the chronic general condition of alveolar atrophy with pus formation which has been variously covered

by such terms as Rigg's disease, pyorrhœa alveolaris, periodontal disease, and periodontoclasia. More recently it has been felt that the term "periodontitis" should be confined to the diseases and inflammations of the periodontal membranes proper and a new term "paradontosis" or "paradontal disease" used to indicate the generalised condition of alveolar destruction seen in the conditions which are commonly called "pyorrhœa."

PERIODONTITIS

Periodontitis may be acute or chronic, local or general. It is produced acutely by trauma leading to crushing of the periodontal membrane; by physical means such as surgical diathermy; by chemical reagents, such as arsenic when used in devitalising the exposed pulp; or it may be bacterial by infection from an injury to the gum margin or, more commonly, by the passage of organisms through the apical foramina of the tooth from a septic pulp. In these circumstances the tooth feels to the patient to be raised in its socket, which in fact it is, by reason of the swelling of the membrane. Upon closing the teeth the offending tooth meets its opposite fellows before its neighbours. Such a tooth is exquisitely sensitive to digital pressure both directly downwards and sideways, and the patient refrains from masticating for fear of pressing upon it.

Acute periodontitis may affect several adjacent teeth as a result of *physical* agencies, such as surgical diathermy when used for the removal of tumours of the gums or for the treatment of pyorrhœa pockets. The greatest care should be taken to use such a type of diathermy current as will remove or desiccate the exuberant tissue without undue coagulation of the subjacent tissues. Sometimes these periodontitic teeth recover, but at other times the sensitiveness lasts so long that patients demand extraction for relief.

When the cause is *traumatic*, there is perhaps only a slight hyperæmia of the overlying gum. Rest will bring relief, although the tooth may remain sensitive for a long period.

When the cause is *chemical*, there is usually some necrosis of the gum margin typical of the escharotic. Arsenic produces a dead grey patch extending from the gingival margin. Sodium peroxide, which is sometimes used as a chemical cauterising agent, produces a gelatinous coagulum which spreads over the gum and ultimately washes away, leaving the bone denuded. Recovery may or may not take place, depending mainly upon the degree of destruction. Injudicious use of arsenic devitalising fibre has been known to produce, not only coagulation of the gum due to leakage of the drug from under the temporary filling used to retain it, but also necrosis of the whole periodontal membrane and the lamina dura of the socket, which ultimately comes away looking like a night-cap of dead bone upon the surface of the extracted root.

When the cause is *bacterial*, the infection may be paradontal due to injury with a septic instrument, such as a toothpick, at the gum margin, but it is more commonly apical and due to invasion of micro-organisms from the pulp via the apical foramina. Sometimes the sepsis appears to break through the dentine laterally and paradontal abscesses are formed; these are seen in radiographs of the socket by the side of the root. Streptothrix infection of the jaws is also said to occur by inoculation into the periodontal membrane from injury at the gum margin.

Sub-acute and chronic periodontitis is produced by a milder degree of the traumatic, physical and chemical injuries which cause the acute condition. An

orthodontic appliance pressing upon a tooth over a long period is an example of *traumatic* origin. Sometimes the root of the tooth becomes added to by a deposition of secondary dentine, but more commonly in orthodontic cases it is absorbed by a rarefying periodontitis. It may or may not be tender to pressure.

Chronic localised periodontitis may also occur around live teeth by *infection* of the periodontal membrane from the gum margin. In its simplest form food-packing in the inter-dental space causes injury to the gingival attachment, and chronic infection of the periodontal membrane results. There is detachment and deep destruction of the supporting tissues of the tooth, including the bone of the socket and a localised pyorrhœa pocket is produced.

Traumatic occlusion, which is the term used to define the effect of undue strain put upon an individual tooth during masticatory effort owing to faulty position of the tooth itself or of its opposite number, or to the strain of some mechanical contrivance, is also responsible for localised periodontitis. A common site is upon the palatal aspect of the root of the central incisor or of the first molar, which may be denuded deeply before the "pocket" is discovered. Sometimes these deep pockets completely undermine the affected root of a molar tooth and, infecting its pulp, give rise to severe pulpitis in a non-carious and otherwise apparently healthy tooth. The remaining roots of the molar may be unaffected and, since they hold the tooth firmly in the bone, the diagnosis is obscure in the absence of a radiograph coupled with a minute dental examination. The process of pocket formation is painless and unobserved by the patient unless the pocket, becoming pent up, forms a retention abscess. Drainage of the abscess either by deep incision or by extraction is indicated.

When the periodontitis is mild and of long standing, two opposite effects are seen: sometimes there is a proliferation of cementum, which encases the lower portion of the root in successive layers, described as exostosis of the root or cementosis; at other times there is a rarefaction leading to an absorption of the root, either evenly from the apex or in a localised patch. Occasionally the two processes alternate, and cases are recorded where absorption of the root in a localised patch or at the apex has been followed by a filling in with adventitious cementum. These teeth may or may not be sensitive to percussion.

PARADONTAL INFECTION—PYORRHŒA

In the healthy young adult with a perfect set of teeth the gums are pale pink with a matt surface and are tightly bound down to the alveolar bone and to the necks of the teeth. There appears to be a process of continued eruption which goes on throughout life, with an elongation of the exposed portions of the teeth. In primitive aboriginal and archaic types with full complements of teeth meeting edge to edge, the normal attrition of mastication serves to grind the teeth short so that their normal tendency to protrude too far beyond the gum and supporting alveolus is counteracted and they remain firm. In modern man, whose upper incisor teeth overlap his lower ones instead of meeting edge to edge, and whose diet is soft and not conducive to masticatory exercise, the teeth merely elongate and, perhaps through leverage and disuse, tend to become looser with increasing years. The atrophy of old age affects the jaws as well as other parts of the skeleton, and this phenomenon must be remembered in assessing the pathogenicity of any given case of paradontosis.

There are three main types of paradontosis: the marginal, the proliferative, and the rarefying. One type, or all three types, may be present in the same mouth.

(1) *Marginal paradontosis.* This is an extension of marginal gingivitis to the deeper paradontal tissues. It is the type identified with chronic general periodontitis due to food stagnation (of Colyer)—it is the "pyorrhœa" of common parlance. Purulent detachment of the supporting tissues by pocket-formation is initiated by bacterial injury in the gingival crevice. The predisposing factors are all those agents which interfere with oral hygiene, ranging from mouth-breathing and ineffective methods of cleaning the teeth to local mechanical obstructions such as tartar and the overhanging ledges of fillings and crowns. In the initial stage of gingivitis the gum margin reacting to injury becomes swollen; its colour may range from dusky red to cyanotic, and when dried it has a glazed surface. Pressure upon the swollen margin causes pus to exude. Examination under the gum with a fine dental probe usually reveals round the neck of the tooth

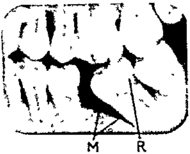

Fig 2886—Skiagram of a deep paradontal pocket (M) under the mesial side of the crown of the second mandibular molar following early loss of the first molar and tilting of the posterior ones. A carious cavity is seen at (R). Both lesions are due to food stagnation

("*Lancet.*")

Fig 2887—Skiagram of the type of paradontosis in the molar region with deep destruction of the alveolus due to chronic Vincent's infection.

("*Lancet*")

a ring or collar of a dark calcareous deposit called serumal tartar or sub-gingival calculus. This concretion, the origin of which is obscure, appears to be highly irritating, and its complete removal is followed by immediate subsidence of the inflammatory reaction in the gums. The ledge of a crown or filling appears to act similarly. It is not clear whether the pocket is formed first and the sub-gingival calculus forms within it, or whether the formation of sub-gingival calculus causes detachment of the adjacent gum and thus produces pocket-formation.

The earliest radiographic sign of infection from the gum margin is a localised widening of the periodontal space extending for a variable distance down the side of the root towards the apex. This is succeeded by a solution of the lamina dura in those portions of the sockets to be affected earliest—i e. the marginal rim—and ultimately by the disappearance of the cancellous tissue subjacent to it. Distribution of the lesion in the teeth of the denture is determined by a variety of exciting factors, similar to those already mentioned and including the uncleansable area below the convexity of the crown of a tilted molar (fig. 2886), when it is

perhaps aggravated by the trauma of faulty occlusion (traumatic occlusion). It may also be seen affecting all the teeth to a greater or lesser degree in the condition of general marginal paradontal disease associated with mouth-breathing or insufficient oral hygiene

Progress of the disease consists in the widening of the paradontal space and detachment of the connective tissue fibres from the affected surface of the root, so forming the characteristic "pocket." The lymphatic system of the periodontal membrane is axial to the root, and the paradontal pockets therefore tend to elongate towards the apex rather than to encircle the roots. The rate of extension appears to depend upon the local and general resistance. A paradontal pocket, however, should not be ignored Under the most favourable circumstances neglect of it will ultimately cause the loss of the tooth, an event of minor importance compared with the fact that the pocket acts as a portal allowing ingress and ultimate entrenchments of infection in the cancellous bone of the jaws. Where a number of teeth are affected the area of absorption becomes considerable. Deep and severe pocketing with a circular erosion of the socket is associated with chronic Vincent's infection, which results in a very destructive type of marginal pyorrhœa (see fig. 2887).

(2) *Proliferative paradontosis.* There is a proliferative type of paradontal disturbance which is seen as a sclerosis affecting the bone more or less uniformly and accompanying a generalised cementosis (exostosis) of the roots of the teeth in those cases of low-grade infection in which resistance is good. It may be associated with the marginal type of paradontosis or be independent of it. Unless the case is complicated by marginal disease, there is no pocket-formation and no disturbance of the gum margin in texture, form or colour. Clinical evidence of the condition is scanty. The percussion note of individual teeth is resonant, but trans-illumination may show them to be abnormally transparent. The diagnosis is clinched by radiography. This condition was known to former observers as "gouty teeth" and is commonly associated with an arthritic diathesis. Removal of the exostosed teeth is properly carried out by the open operation. Ordinary extraction by means of forceps is difficult and traumatic, for the bone has become denser and unyielding and the teeth themselves are often brittle. Healing of the socket is also slow, and excessive sclerosis interferes with the vascular supply of the alveolar bone and is largely responsible for the painful sequela to extraction in these cases known as "dry socket."

(3) *Rarefying paradontosis* In contra-distinction to the proliferative type of paradontosis, which appears to be associated with a good resistance, there is a rarefying type which is always associated with poor resistance and is therefore seen most often in debilitated patients. It is not necessarily associated with marginal disease, and the earliest sign is radiographic rather than clinical. It manifests itself as a general even thickening of the periodontal membranes of all the teeth In its earliest stage the "black" line of the periodontal shadow appears in the skiagram to be two or three times its normal thickness, with a corresponding reactionary thickening of the lamina dura if the resistance of the patient is still responsive (fig. 2888*a*). Later, however, the periodontal space may appear ten or twelve times its normal width; its wall of lamina dura has disappeared, and the root, instead of being clearly defined, has a "fuzzy" appearance (fig. 2888*b*). Teeth in this state may cause no local symptoms, although from time to time, as the periodontal membranes become congested, they may "feel on edge." Percussion in an

axial direction with a metal instrument elicits a dull note, because of the cushioning of the swollen periodontal membrane, and on lateral palpation the teeth are slightly loose in their enlarged sockets. There is often an absorption of the dental apices. There appears to be a close relation between this condition and toxæmia of other origin, notably intestinal. In advanced cases a heavy growth of streptococci is present in the alveolar sockets, and there is a very high percentage in the fæces. Remedial dental treatment alone is only palliative. These cases call rather for guarded removal of the teeth with due protection of the patient from the effects of the post-extractive bacterial shower. Subsequent treatment should be directed towards eradicating the deep-seated infection from the jaws and raising the

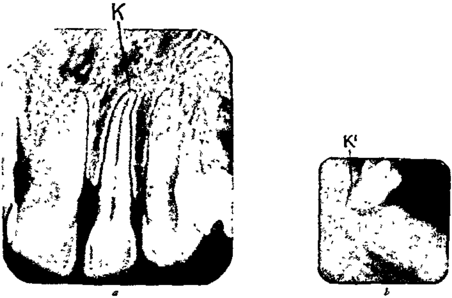

Fig. 2888.—(*a*) Skiagram of upper incisors and canines showing an early stage of general paradontosis. The periodontal membranes are evenly thickened (K) without loss of continuity in the lamina dura, which is frequently sclerosed (*b*) Later stage of the same condition, sclerosis having extended into the neighbouring cancellous tissue, but rarefaction, accompanied by the formation of a granulomatous membrane (K¹), and loosening of the tooth, has supervened.

("*Lancet.*")

patient's resistance. By the time extraction is considered, these patients are usually gravely debilitated and, if necessary, they should first be treated by raising their resistance by sera and physio-therapeutic measures.

An exceptional type of gross rarefaction accompanied by hypertrophy of the gums affecting the permanent teeth has been seen in an adolescent in whom the enlarged gums formed longitudinal sausage-like swellings on the buccal and lingual aspects of the permanent teeth. The hypertrophic condition appeared to be confined to the gingivæ proper and not to involve the buccal mucosa, which was overlapped by the redundant swelling. The consistency of the swollen gum, instead of being densely fibrous as is usually seen, was myxomatous and gave the mass, which was pale pink in colour, a peculiar translucency like that of the umbilical cord. The other prominent feature was the progressive marginal absorption of the alveolus of the teeth leading to their ultimate exfoliation. The teeth, as it were, floated out of the enlarged sockets into the hypertrophic tissue (see *fig.* 2889), and were ultimately shed. As soon as the tooth had been shed, the

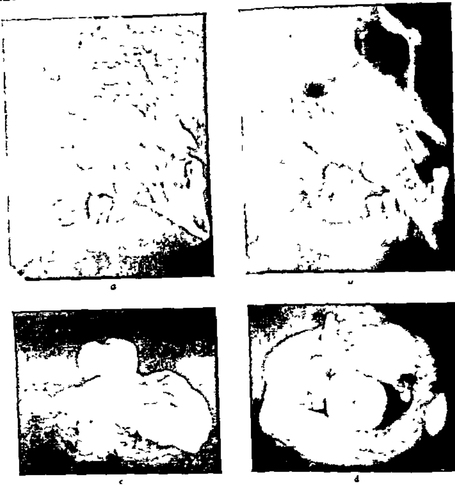

FIG. [illegible].—(a) AND (b) SKIAGRAMS OF A RARE CASE OF PROGRESSIVE RAREFACTION OF THE ALVEOLUS AROUND THE PERMANENT TEETH ACCOMPANIED BY MYXOMATOUS HYPERTROPHY OF THE GINGIVÆ. (a) THE FIRST MOLAR HAS ALREADY BEEN LOST AND THE SECOND MOLAR SOCKET IS UNDERGOING RAREFACTION. (b) THE SAME TOOTH FIFTEEN MONTHS LATER, WHEN RAREFACTION HAS COMPLETELY DESTROYED THE SOCKET OF THE SECOND MOLAR WHICH HAS "FLOATED" OFF INTO THE HYPERTROPHIC GUM. (c) AND (d) PHOTOGRAPHS OF THE SPECIMEN AFTER REMOVAL.

swelling subsided, but it recurred again when a further tooth erupted. Eventually the remaining teeth were extracted and the redundant tissue was excised. The edentulous alveolar ridges, except that they were greatly absorbed as in old age, presented a normal appearance and remained covered by firm muco-periosteum showing no tendency to enlargement.

THE SURGICAL TREATMENT OF PYORRHŒA

For purposes of treatment, paradontal infections may be divided into two groups according to the morbid anatomy:

In one group, the lesion is that of a generalised absorption of the sockets leading to widening of the periodontal space. A so-called "thickening" of the periodontal membrane is seen in the skiagrams. There is no initial "pocketing" in the gums nor loss of bone from the inter-dental crests. The disease appears to affect the whole socket uniformly and is general throughout the denture. The

origin is obscure, but it is constitutional rather than local, and toxæmia from some other source, such as the large bowel, has been suggested as an associated if not a contributory factor. Patients with this type of paradontal disturbance are usually in a debilitated state and local dental treatment is only palliative. A more thorough practice of oral hygiene may improve the condition by stimulating the gums and lessening the pabulum for bacteria. Much assistance may be obtained from the administration of an autogenous vaccine and by the application of intra-oral diathermy with the special electrodes invented by the writer. In the more severe cases, however, the prognosis is bad and extraction of the teeth, together with measures for eliminating residual sepsis from the alveolar bone, should be carried out promptly.

In the second group, the lesion is that of a localised absorption of the socket, beginning at the margin and progressing towards the apex of the affected teeth. In contrast to the first group, not every tooth in the denture is necessarily involved, and the lesion is often locally aggravated in a portion of the particular socket. In these places the gum is detached and clinical examination shows pocket-formation. The cause is apparently local, and the patients are not necessarily either ill from toxic absorption or constitutionally debilitated as in the previous group. Local surgical treatment is indicated and may be coupled with such other therapeutic assistance as the progress of the case appears to suggest

Local treatment is as follows: A full set of intra-oral films is taken, and by reference to these, as well as by a clinical examination with a fine seeker, the depth and extent of the various pockets are determined. The intention is to cut out the whole of that segment of gum which is found to be detached from the tooth' so as to eradicate the undraining space and to leave the affected portion of the root bare and easy to clean. Although any portion of the individual sockets may be affected, it is common to find the deeper pockets inter-dentally, and it is therefore convenient to cut out the inter-dental papilla so as to leave between adjacent teeth a triangular space, which must be kept clean by the patient, instead of two pockets which he cannot clean. At the same time, the roots of the teeth are curetted to free them from calculus and carious cementum, and the bone forming the base of the pockets is curetted free from granulomatous material. With suitable mouth-washes and gingival massage the gums heal firmly and, provided the patient carries out a careful daily hygiene, a successful result may be anticipated. In practice, where a number of adjacent teeth are affected, two methods are offered:

(1) *Gingivectomy.* With a conveniently shaped, double-edged knife, an incision varying with the depth of the consecutive pockets is made in the muco-periosteum on the buccal side of the alveolus supporting the teeth and a similar incision on the

Fig. 2890.—GINGIVECTOMY.

(1) Type of gingival hypertrophy with back formation suitable for treatment by this operation.
(2) Method of removing the detached gingivæ.
(3) The healed gums.

palatal or lingual aspect. In both instances care is taken to force the blade well between the teeth in the inter-dental space so that the inter-dental pad of gum is cut loose from the bone. By means of a sharp raspatory the portion of gum forming the gingival margin with the inter-dental papillæ is stripped away, the papillæ being incised where necessary to allow complete detachment from the teeth (see fig. 2890). The roots of the teeth and the alveolar bone are thoroughly scraped, and then irrigated with a mild antiseptic lotion. Healing is by granulation and ultimate epithelialisation.

(2) *Gingivoplasty.* In this operation the inter-dental papillæ are incised transversely and the gums on the external and internal aspects of the teeth are freely peeled back so as to expose the roots and the supporting alveolus. With the flaps suitably retracted the inter-dental bone and the roots of the teeth are curetted, after which the gum is returned to place. Redundant tissue is trimmed

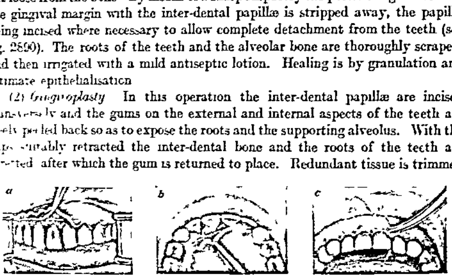

Fig. 2891.—Gingivoplasty.
(a) Showing gum reflected on buccal aspect.
(b) Showing gum reflected on palatal aspect.
(c) Method of suturing.

away with scissors and fine sutures are passed from side to side through the inter-dental spaces so as to hold the internal and external flaps tightly in place against the teeth. Healing is by first intention (fig. 2891).

Both operations have their advantages. Gingivectomy is more applicable to the treatment of individual pockets; gingivoplasty is more suitable to extensive cases. In both cases pre-operative cleansing of the field by scaling and the filling of carious cavities and post-operative hygiene and massage are essential to success. Not only should the patient be directed how to keep the necks of the teeth scrupulously free of food-debris, but he should be encouraged to massage the gums by brushing them and to cornify the inter-dental papillæ by rubbing through the spaces with wooden toothpicks and with dental tape.

IMPORTANCE OF DENTAL SEPSIS IN RELATION TO GENERAL SURGERY

Although the general surgeon may not be called upon to carry out himself any of the afore-mentioned operations, yet it is to his advantage and that of the patient for him to have knowledge of dental disorders. This is of particular importance in those cases of clean wounds failing to heal by first intention. As an illustration of this, reference may be made to eye operations, for example, cataract extraction, where the presence of hidden dental sepsis has resulted in post-operative iritis and even cyclitis and keratitis punctata, resolution not occurring until the dental focus had been eradicated. In a rather different sphere English and American literature contains numerous references to dental toxæmia producing delayed union and non-union in fractures of the long bones.

Coming to the more obvious, the extraction of involved teeth and the eradication of all local sepsis is the first step in the treatment of fractured jaws. More-

over, until this local sepsis has been cleared, no attempt at union can be expected. Again, in such a premeditated operation as that of partial gastrectomy, a routine search for a septic focus in the mouth, its elimination, if found, and in any case pre-operative scaling and polishing with a correct course of dental hygiene will in many cases not only guard the patient against the effects of swallowed poisons but relieve him from the toxæmic debility and anæmia that is occasioned by oral sepsis. Even when the dental sepsis is insufficient of itself to initiate harm it has often been demonstrated to constitute the latent factor which has swung the balance to the side of infirmity. Moreover, in all major operations where general anæsthesia is used, the danger of aspirating septic material from the mouth is always present.

To summarise, in the wide practice of surgery it appears that oral surgery has assumed a new importance as a local field, but it is my belief that it will attain a far greater distinction in its relationship to systemic medicine.

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PART XXXV

VENEREAL DISEASE

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GONORRHŒA

by

A. MALCOLM SIMPSON

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SYPHILIS

by

SURGEON-COMMANDER J. B. CRAWFORD, R.N.

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Section 1

GONORRHŒA

by

A. Malcolm Simpson

CHAPTER I

Treatment of the Recent Acute Case

Gonorrhœa is a contagious disease caused by a specific organism, the gonococcus of Neisser. The common site of infection is the genito-urinary tract in both males and females.

ANATOMY

Before studying the treatment of the disease in the male it is useful to have an understanding of the surgical anatomy of the male urethra.

The urethra is divided into two portions, anterior and posterior, the point of division being the compressor urethræ muscle which surrounds the membranous urethra (see fig. 2892).

The *anterior urethra* is six inches long, and consists of: (1) the meatus urinarius, the narrowest portion (average calibre 24 Charrière); (2) the fossa navicularis, one inch long (calibre 30-35 Charrière), and containing on its roof one large pit, the lacuna magna; (3) the penile portion (calibre 27-30 Charrière), on the roof of which are numerous glands; and (4) the bulbous portion (calibre 40-45 Charrière), usually containing only a few glands on its roof. The glands of Cowper open into the floor of the bulbous portion. The compressor urethræ is a powerful voluntary muscle which easily passes into spasm, and can only be relaxed by an effort of will or by the application to the mucous membrane of novocaine, percaine, or similar drugs. It encloses the membranous urethra which is about three-quarters of an inch long (calibre 27-30 Charrière), and only a few glands open into it.

The *posterior urethra* (calibre 35-40 Charrière) is about one and a half inches long, and its mucous membrane is highly sensitive and absorptive. There are only a few glands in the roof and sides. On the floor lies the verumontanum, an erectile ridge. The sinus pocularis or uterus masculinus is a funnel-shaped depression—roofed or unroofed—in the verumontanum. The position of the ejaculatory ducts in relation to the verumontanum may be one of four types: (1) a medium sinus pocularis, showing on its lips the orifices of the ejaculatory ducts (the commonest type); (2) an open sinus pocularis on the summit of the verumontanum, the ejaculatory ducts opening on each side of the sinus under the summit; (3) there is no medium sinus pocularis, the ejaculatory ducts opening on the middle walls of the verumontanum ("Diver's Helmet"); or (4) a medium sinus pocularis

with ejaculatory ducts opening on the floor of the sinus. The posterior urethra is cut off from the bladder by a weak involuntary muscle, the internal sphincter of the bladder. It is a potent safeguard against the spread of urethritis to the bladder, the bladder mucous membrane being also highly resistant to the gonococcus.

On the roof and sides of the anterior urethra—and occasionally on the floor—are numerous recesses, the lacunæ of Morgagni, the largest of which is the lacuna magna. In addition there are, on the roof, sides, and occasionally on the floor, ten or fifteen openings of the glands of Littré which secrete mucus, the ducts opening towards the meatal orifice. The opening is often in the centre of one of the lacunæ. The urethra is lined by a mucous membrane, showing stratified epithelium

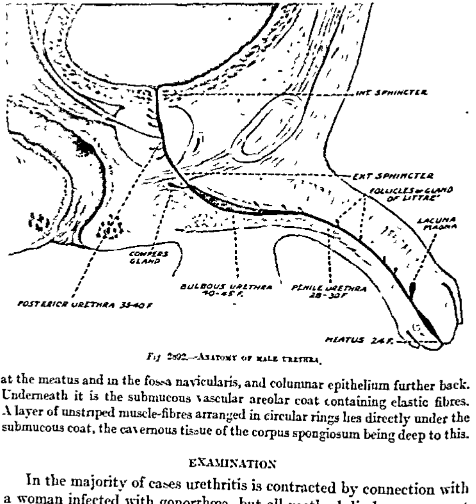


Fig. 2692.—Anatomy of male urethra.

at the meatus and in the fossa navicularis, and columnar epithelium further back. Underneath it is the submucous vascular areolar coat containing elastic fibres. A layer of unstriped muscle-fibres arranged in circular rings lies directly under the submucous coat, the cavernous tissue of the corpus spongiosum being deep to this.

EXAMINATION

In the majority of cases urethritis is contracted by connection with a woman infected with gonorrhœa, but all urethral discharges are not necessarily due to the gonococcus, and it is essential that before treatment is begun the examination of a patient complaining of this condition should be a careful one as to the history, the symptoms, and especially the bacteriological examination of the discharge. Note is taken of the incubation period—2 to 7 days (usually 3 to 5) in

gonorrhœa, and generally 10 to 21 days in non-gonococcal urethritis. Absence of pain and burning micturition may occur in recent gonococcal infections and is not evidence against gonorrhœa. Enquiry should be made as to whether antiseptics have been injected following coitus.

The patient should be stripped, the external genitals examined, and note made as to the nature of the discharge, smears being taken. If there is a prepuce this is cleansed and the sub-preputial sac and glans penis examined, the presence of balanitis being duly noted. The penis is palpated to ascertain if there is any thickening of the dorsal lymphatics, and the lymphatic glands in the groin are also felt.

The meatus is next examined for the presence of any para-urethral canals, for redness and œdema of the lips, or the presence of any sore. *Palpation should reveal any induration inside the meatus. The meatus is then cleaned, and a sterilised platinum loop, or sterile cotton wool* on a holder, gently inserted into the urethra. The specimen so obtained is used for making smears and cultures. If no discharge is seen, the patient then passes urine, and if no pus is found in this, the case is one of balanitis. A smear is in most instances sufficient to make a diagnosis in acute cases, but a culture may also be required for social or medicolegal reasons. In acute cases of gonorrhœa a film, stained very quickly by Loeffler's methylene blue, showing pus cells filled with intra-cellular diplococci, is sufficient for diagnostic purposes, though a Gram stain should, if possible, be carried out as well (see frontispiece).

If on examination no gonococci are found, a diagnosis of non-specific urethritis may be made, and it may be advisable here to give the causes. They are as follows:

(1) Excessive indulgence in sexual intercourse, associated with consumption of *alcohol, and followed by prophylactic injections of strong antiseptics. Inflamed* Littré's glands and distended lacunæ, seen urethroscopically, are very suggestive of this condition.

(2) The passage of uric acid or oxalate crystals, a heavy phosphaturia, or the taking of asparagus, watercress, strawberries, and such drugs as cantharides or turpentine.

(3) The injection of irritating chemicals, such as strong perchloride of mercury or silver salts.

(4) Trauma from foreign bodies and catheters.

(5) *Infection with protozoa and fungi, viz. Trichomonas vaginalis.*

(6) The result of chronic non-specific prostatitis and vesiculitis due to B. coli, streptococci, staphylococci or B. tuberculosis.

Finally, *a general view is taken of the skin of the patient's trunk or* limbs to see whether there is any evidence of present or past syphilitic lesions.

MAIN LINES OF TREATMENT

The basis of treatment in gonorrhœa consists of: (1) mechanical antiseptic cleansing of the infected tract; (2) adequate drainage of the infected area; and (3) the raising of general tissue resistance by all means possible, including the help of general and specific remedies.

A new form of treatment may here be mentioned, of which the writer has not yet had any practical experience—namely, the production of artificial fever by means of a Kettering "Hypertherm." The patient is exposed to a temperature of 106° F. for six to eight hours at each session, with intervals of three to seven days between each, the average number of sessions being five. Very satisfactory results are reported (Desjardins and others; *Journ. Amer. Med. Assoc.*, March 16, 1935.)

In describing the treatment of recent acute gonorrhœa, it is best to consider the six clinical types of the disease in its acute stage:

(1) *Aborted acute gonorrhœa;* (2) *Incompletely aborted acute gonorrhœa;* (3) *Acute anterior gonorrhœa with complications;* (4) *Latent posterior gonococcal infection;* (5) *Acute anterior and posterior infection—mild; and* (6) *Acute anterior and posterior infection—severe, with complications.*

Instructions to Patient.

The detailed treatment of the various types is dealt with later in this chapter. Success, however, also depends upon the patient's mode of life, and the following instructions should be handed to him in writing and made clear to him in every instance:

General Warnings.

(1) Even though there is no urethral discharge, you may still be infectious.

(2) Do not convey discharge from the fingers to the eyes.

(3) Be careful not to convey infection to other people by towels, baths or lavatory seats.

Directions as to mode of life.

(1) Do not drink alcohol in any form.

(2) Refrain from any kind of sexual excitement.

(3) Do not ride a horse or bicycle.

(4) Avoid such articles of diet as curry, ginger, pickles, vinegar, mustard and pepper. Meat will do you no harm.

(5) Take plenty of fluids, especially plain water and the ordinary mineral waters—4 to 8 pints daily.

(6) The best results are obtained if you lie up in bed during the first three weeks.

(7) If you suffer from painful erections while in bed, you will find relief in passing water.

USE OF DRUGS

Drugs alone will not cure gonorrhœa. Sandal-wood preparations are only useful in diminishing the discharge, especially if there is greatly

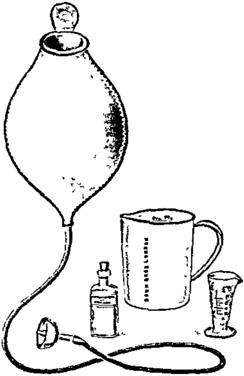
increased frequency of micturition and intense pain at the end of the act, as in hyper-acute cases with a red and swollen mucous membrane. The preparations I have found most useful are arheol capsules and elixir saw palmetto et santal. Probably the best general drug is potassium citrate given in a mixture with potassium bicarbonate, tinctura hyoscyami and infusio buchu. This is a good routine internal treatment. Pyridium has been used largely in the last few years, and it seems to be of undoubted service as it has been shown actually to impregnate the tissues of the prostate and seminal vesicles.

TREATMENT OF TYPES 1, 2 AND 3

Anterior Irrigation (of Janet).

It is essential to have practice in this method for the treatment of gonorrhœa to be successful. The apparatus required consists of a glass, metal or rubber receptacle capable of holding at least two to four pints of fluid, and of being raised

Fig. 2893.—Janet's irrigation outfit



four to five feet above the level of the patient's urethra (fig. 2893). Fitted to the lower end of this receptacle is six to nine feet of rubber tubing provided with a strong clip, to the free end of which is attached a metal nozzle and shield, all in one piece, or a metal shield with separate nozzles. In anterior irrigation the patient lies on a couch with a receiver—preferably boat-shaped—between his legs. If treating himself he stands or sits. For anterior irrigation the container should be raised two to three feet above the level of the urethra, the operator grasping the rubber tubing above the stem of the nozzle, releasing the clip, and, with his left hand, holding the penis. He opens out the meatus and inserts the nozzle,

allowing the fluid to flow into the urethra. It flows as far as the compressor muscle, where, meeting resistance, it turns back and flows round the mouth of the nozzle. By quickly pressing the nozzle to and fro in the urethra and then withdrawing it slightly, the urethra is alternately " ballooned " and collapsed, so that the fluid bathes the whole of the mucous membrane. The greatest gentleness must be used, especially if the urethra is acutely inflamed, and the treatment may be started with the container held at a height of only one foot.

Posterior Irrigation.

The irrigator is raised to a height of three to four feet above the patient's urethra When the anterior urethra has been washed out with one pint, the nozzle is advanced until the meatus is blocked. The patient is then told to relax his muscles and to make the action of passing water without straining. (It may be necessary to use a drachm of 2 per cent novocaine or 1 in 1000 percaine inserted into the urethra and milked down into the bulb.) The muscles being relaxed, the fluid passes into the bladder, and when this is nearly full the patient expels the fluid in the ordinary way.

Aborted Acute Gonorrhœa (Type 1). If the discharge is of less than 12 hours duration, and by the test to be described the infection is proved to be limited to the first two or three inches of the anterior urethra, the abortive treatment by instillation of some silver preparation and by irrigation with potassium permanganate should be tried. If, however, the history of the discharge is longer than 12 hours, and if there is any suspicion of early posterior infection, abortive treatment should not be considered.

Urine Tests. There are two tests used to distinguish between anterior and posterior infection: In the first the anterior urethra is washed out with 2 pints of 1 in 8000 oxycyanide of mercury, and when the washings are clear the patient passes urine. If the urine is clear, there is no posterior infection. If there is a purulent haze, then there is an anterior and a posterior infection. The second, a rough test, is called the " three-glass test." The patient should pass not more than 3–4 oz. into the first glass. The three examples below illustrate how the findings may be interpreted :

(1)	First glass : Haze Second glass : Clear Third glass : Clear	Probably an anterior urethritis.
(2)	First glass : Haze Second glass : Haze Third glass : Clear	A severe anterior only, or anterior and probably posterior urethritis.
(3)	First glass : Haze Second glass : Haze Third glass : Haze	Probably anterior and posterior urethritis, and possibly trigonitis.

In incompletely aborted acute gonorrhœa (Type 2) the test consists of the patient holding urine for at least two hours. The urethra is then

compressed at the peno-scrotal junction and is washed out with 2 pints of oxycyanide of mercury, 1 in 8000, until the washings are clear. The anterior urethra is next washed out with the same solution of oxycyanide, but with no compression at the peno-scrotal junction. This washing is examined to see if it is clear. The patient then passes urine. If the second oxycyanide washing is clear and the urine passed is clear, abortive treatment should then be started.

Irrigation Treatment. The anterior urethra having been washed out with 2 pints of 1 in 6000 permanganate of potash, flowing from a height of 3 feet, 5 cc. of silver nitrate, 5 grs. to the ounce, or neoreargon 5 per cent, or neoprotosil 10 per cent. or argyrol 10 per cent is instilled into the anterior urethra, which is gently ballooned out by a blunt-pointed, all-glass urethral syringe, and the solution held for 5 to 10 minutes by means of a clip being applied to the glans penis, a few drops being allowed to trickle out from time to time to make certain that some of it comes in contact with the fossa navicularis.

Twelve hours later an anterior irrigation is given of 2 pints of 1 in 6000 potassium permanganate. This technique should be repeated for three days, the contra-indication being hæmorrhage or marked œdema of the penis. If on the fourth day there is, on examination of an all-night retention of urine, only a thin discharge merely showing squamous epithelium and no gonococci, it is probable that abortive treatment has been successful, and the anterior irrigation with 2 pints of 1 in 6000 potassium permanganate should be continued for three or four more days.

Should the discharge still show no pus cells or gonococci, the treatment should be suspended and the patient examined 24 hours later. If by that time there is no relapse, and if urethroscopic examination shows no evidence of infected follicles, and palpation of the urethra on a straight French steel bougie, Charrière 22, no peri-urethral swelling, the patient should take a provocative dose of alcohol. In the absence of a relapse during the next 48 hours he can be passed as cured.

Two objections to abortive treatment are the pain and the fact that if it is unsuccessful a posterior infection often follows. In a large majority of cases—especially those where the attack is a second one and the anterior urethra is smooth—abortive treatment with Janet's irrigation, using potassium permanganate (1 in 6000–1 in 4000) twice daily, is often successful.

Incompletely Aborted Acute Gonorrhœa (Type 2). If, following three days' abortive treatment, a discharge containing gonococci is present, or where non-specific prostatitis can be excluded and pus without any

gonococci is evident, then anterior irrigation with 1 in 6000 potassium permanganate should be continued for another 14 to 21 days. If at the end of that time there is no purulent urethral discharge on examination of an all-night retention of urine, treatment should be suspended and, in the absence of a relapse, further examination by urethroscope and palpation should be made as just described.

Acute Anterior Gonorrhœa with Complications (*Type* 3). In this type the infection remains anterior, but after three or four weeks' daily anterior irrigation a urethral discharge containing gonococci still persists. In such a case there is some complication present in the anterior urethra. It may be any one of the following conditions: (1) peri-urethral infiltrations ("peas"); (2) peri-urethral abscess; (3) inflamed Littre's glands (or lacunæ of Morgagni); (4) soft infiltration; (5) para-urethral follicles; or (6) old hard stricture.

In Type 3 infections, a rectal examination should always be made, even though the case appears to be one of anterior infection only. A straight steel bougie should be passed, and the urethra palpated on it. Any peri-urethral swelling demands a urethroscopic examination, but this should not be made until all the acute inflammation has subsided, and until the urine, while irrigation is being carried on, shows no thick purulent haze.

Before dealing with the anterior complications of acute gonorrhœa it will be as well to give a short account of the uses of urethroscopy:

USE OF THE URETHROSCOPE

The instrument recommended is Kidd's anterior urethroscope, an illustration of which will be found in Volume II, page 2706.

The great advantage of a urethroscope such as this is that air is used to distend the urethral canal. This drives the walls of the canal away from the instrument and enables the observer to determine accurately whether any part of the canal is properly dilated or not. It helps in judging whether lacunæ or the openings of Littré's glands are infected, and makes destruction of infected follicles comparatively easy.

Having first centred the light of the urethroscope, the observer blows up the bellows to full distension, and, if possible, passes a 24 Charrière urethroscope tube. Having withdrawn the obturator, he attaches the urethroscope and then turns on the air. The bulbous urethra, blown out with air, is now seen with the compressor urethræ lying at the deepest point. As the urethra is examined, the observer should gradually withdraw the tube, noting principally the roof of the urethra and the distensibility of the different parts.

Normal Appearances (fig. 2891A).

The compressor urethræ is seen at the base of the bulb alternately contracting and relaxing, and the mucous membrane has a star like appearance. The bulb appears like a cavern, its floor being pinkish-yellow with longitudinal leashes of vessels.

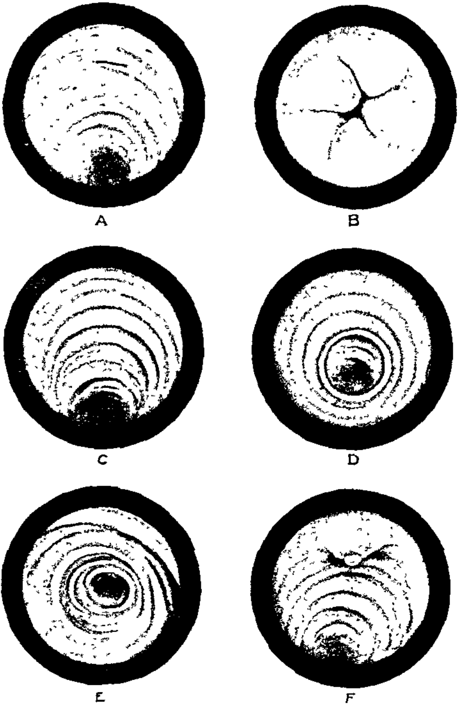


Fig 2394.—Urethroscopic Appearances.

A. Normal appearances.
B. Soft infiltration.
C. Bridle or crescent stricture.
D. Annular stricture.
E. Tunnel stricture.
F. Infected follicle.

The openings of Cowper's glands can rarely be seen, though the circular involuntary muscles lying outside the mucous membrane are easily observed. When more air is admitted, the circular muscle-fibres are flattened out and the walls appear smooth and glistening and of a yellowish-pink colour. Occasionally one may see the mouths of glands on the roof. The penile urethra appears as a cylindrical tube, narrower than the bulb, and the circular muscle-fibres and smooth glistening mucous membrane resemble those of the bulb. On the roof the openings of Littre's glands can easily be seen, arranged in a single row, while a few may be demonstrated in the lateral walls of the floor. A few large pits or lacunæ of Morgagni may be observed glistening with mucus. In the fossa navicularis is seen a large pit which opens on the roof—the lacuna magna.

Pathological Appearances.

(1) *The Early Acute Case* In this condition the whole mucous membrane appears somewhat hyperæmic and sodden. It dilates moderately with air. On the roof may be seen several tiny beads of pus lying in the mouths of the openings of Littre's glands, surrounded by a red areola.

(2) *The Later Sub-Acute Case* After six weeks, in addition to the above appearances, it may be noted that the wall of the bulbous and penile urethra does not dilate properly with air, and that there are red and œdematous masses giving the appearance of hæmorrhoids bulging in the lumen of the urethra. This condition is a soft infiltration or stricture.

(3) *Urethritis of Six Months' Duration.* A portion of the canal does not dilate properly, but its walls are smooth and pale pink. There is no œdema, and no fibrous tissue edge is seen. This is the intermediate type of stricture.

(4) *Urethritis of Over a Year's Duration* In these cases a fibrous stricture may be found of the various types described in Volume II, page 3074.

Rare urethroscopic appearances (unconnected with gonorrhœa) are: Warts, cysts, leukoplakia, polypi, angiomata, and "millet seeds"—tiny grey bodies of lymphoid tissue.

TREATMENT OF ANTERIOR COMPLICATIONS

The six anterior complications enumerated under Type 3 (see page 5234) will now be discussed.

Peri-urethral Infiltration and Abscesses (fig. 2895).

In the average individual no glands or lacunæ are found on the floor of the urethra except Cowper's glands. Sometimes, however, they are present, when they are usually of large size. If one of these glands is infected, a peri-urethral infiltration may form. When a peri-urethral nodule is felt, a straight steel bougie (Charrière 22 to 25) should be passed, and gentle massage done over it. The bougie is then taken out and a fenestrated urethral tube is passed, with rubber bulb attached, the meatus being completely blocked (fig. 2896A). The rubber bulb is squeezed, and the vacuum so produced is maintained for five minutes. The tube is then removed and an anterior irrigation given. This treatment is carried out daily and a cure may often be effected in two to three weeks If, however, such measures are ineffectual, the nodule

may increase in size until a fluctuating swelling (peri-urethral abscess) the size of a walnut is formed. This should be opened by an incision in the skin, a straight steel bougie being held in the urethra as a guide.

The infected gland may persist as a small, hard, pea-like nodule (" peas "), the opening of the urethra being closed for long periods and

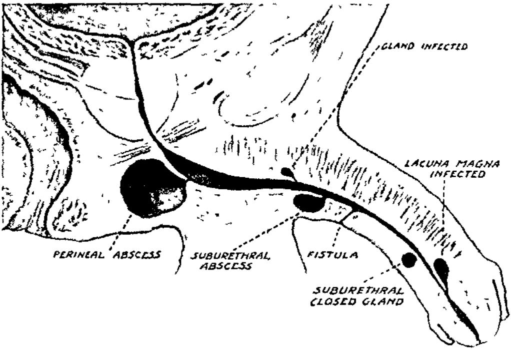


Fig. 2895.—DIAGRAM TO ILLUSTRATE THE COMPLICATIONS CAUSED BY INFECTED FOLLICLE.

then discharging again, giving rise to an attack of urethritis. This relapsing condition may, and often does, persist for many years. In such cases, a straight steel bougie is passed, the small nodule is kept fixed on the bougie, and, under local anæsthesia, a crucial incision is

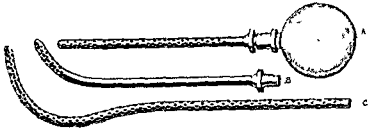


Fig 2896 —SUCTION APPARATUS.

made down to the instrument. A tiny drop of pus or a little discoloured blood may be seen. A fine probe coated with solid silver nitrate, or a cautery point, is then passed down to the bougie, and the tract and surrounding area are thoroughly cauterised. A small gauze drain is kept in for two or three days, and the wound rapidly closes up. There is little danger of the formation of a fistula. If, however, a sinus should occur,

either following this operation or as the result of the infected gland bursting of its own accord on the outside, then a straight silver bougie coated with silver nitrate, or a cautery point, is passed down to the bottom of the sinus and the track thoroughly cauterised. This procedure is repeated in a few days' time. If this fails, a catheter should be tied into the bladder for a few days until the fistula is healed. There may be a stricture in the neighbourhood of the sinus, and this must be treated at the same time.

Inflamed Littré's Glands and Lacunæ Magna.

Urethroscopy reveals the condition described in "early acute cases." In treatment the use of a straight French bougie, together with massage followed by suction, may prove successful. If, however, the condition still persists, it is necessary to probe the infected glands and lacunæ through the urethroscope. The wire which is used for probing is heated, and silver nitrate is fused on to it. When the urethra is distended with air, the swollen mouths of Littré's glands are plainly seen exuding pus. The lacunæ may also be seen distended with pus. The probe is then moved down on to the purulent swelling, the urethral tube being manipulated so that the probe sinks well into it. A little blood and a white area result from the cauterisation by silver nitrate. An anterior and posterior irrigation with 1 in 8000 potassium permanganate is immediately given, and the daily anterior irrigation with 1 in 6000 potassium permanganate is continued. Within twelve hours of this cauterisation, a marked reaction occurs, constituting a profuse discharge of thick pus with blood, which subsides after forty-eight hours.

This small operation may be repeated in a week's time if urethroscopy shows any infected gland or lacuna. When the condition is definitely cured a small scar is left. There is no danger of stricture following this operation.

Soft Infiltrations.

Urethroscopy reveals the condition described on page 5236 under "the later sub-acute case." At first, treatment consists of the passage of a straight steel bougie every third or fourth day, with daily anterior irrigation. After two or three weeks a straight Kollmann irrigating dilator should be used. This three-bladed dilator is constructed so that the blades pass through a small meatus (24 Charrière) and can, when the instrument is in place, be screwed up to 30–45 Charrière according to the part of the urethra to be dilated. This instrument must be used with the utmost gentleness. It must never be employed in the acute stages or when there is a purulent haze in the urine. No local anæsthetic must be employed, as this will numb the patient's

sensations and might allow the urethra to be torn, resulting in serious bleeding. The patient should experience only a slight discomfort and stretching. The treatment is given every fourth to seventh day, and the dilatation must be very gradual, 1 to 2 mm. increase being made at each treatment. Slight bleeding is an indication for increasing the intervals and making the dilatation more gradual. The cure of a soft infiltration should take about four to six weeks, and the patient should afterwards be kept under observation, so that any subsequent contraction can be seen and treated by the passage of curved steel bougies.

Para-urethral Follicles.

Associated with maldevelopment of the glans penis and urethra are found blind pits lined by epithelium and usually ½-inch in length. They are mostly found on the floor and sides of a hypospadial urethra. When infected, redness and œdema appear round the follicle, and pus is seen issuing forth, sometimes giving the appearance of a chancre or chancroid. If left alone the abscess may burst and resolve, and it often relapses for an indefinite period. The chronic induration of the abscess wall with a closed opening may form a small fibrotic tumour. These pits can be easily destroyed by a probe on which is fused silver nitrate, or by the actual cautery.

Old Hard Stricture.

A full account of the treatment of this condition appears in Volume II, page 3074.

TREATMENT OF TYPES 4, 5 AND 6

The above types include *latent posterior gonococcal infection* (Type 4), *acute anterior and posterior infection—mild* (Type 5), and *acute anterior and posterior infection—severe, with complications* (Type 6).

The conditions which predispose to these infections are sexual intercourse and excitement, consumption of alcohol, riding, heavy manual work, rough instrumentation, and massage of the prostate undertaken too early.

As the examination of the prostate in posterior urethral infections is of the greatest importance, being the key to their successful treatment, a short account will first be given together with the technique of the examination and massage of this organ, and the appearance of the fluid expressed from it.

Examination of the Prostate and Seminal Vesicles

On palpating the prostate and seminal vesicles from the rectum we feel on the upper border of the gland a notch lying between the upper poles of the lateral lobes. Extending beyond this notch are the seminal vesicles (in the healthy state

just palpable), the ducts of which converge towards the mid- or urethral line. Below the seminal vesicles are the dilated extremities of the vasa deferentia.

Types of Prostatitis and Vesiculitis.

The following are the chief conditions met with on palpation: (1) The prostate is slightly enlarged and tender, generally soft, with a few small scattered hard areas, the seminal vesicles being barely palpable; (2) The prostate is definitely enlarged, tender and boggy; (3) Little change is noticeable in the prostate itself, but one or both vesicles are hard, cystic and pear-shaped; (4) A central hard mass is felt surrounded by normal prostatic tissue (encysted abscess); (5) The prostate is very tender, enlarged, tense and globular; and (6) A small soft area is felt with a dip in the anterior rectal wall (an old prostatic abscess which has burst into the rectum).

Massage of Prostate and Vesicles. The prostate and seminal vesicles must not be massaged in the acute stages, and it is rare for this procedure to be undertaken before the fifth week from the onset of the discharge in a recent acute infection, even though on palpation the prostate and vesicles give no evidence of acute inflammation. Special care is required in massage where there is, in very tender prostates, calculous or tuberculous prostatitis, and in cases of fibrous or hypertrophic prostates. In each instance massage should either not be undertaken, or be carried out with special care.

The technique of massage is as follows: The patient should be placed in the knee-elbow position, or bending over with his hands touching his toes. A gloved finger is passed well up to the upper pole of the lateral lobes, and is then brought down in a direction parallel to the mid-line, the lateral lobes being emptied in three or four strokes. After both lateral lobes have been emptied in this manner, the finger is passed well up and outwards beyond the median sulcus of the prostate, and is brought down several times in order to empty the seminal vesicles, with some pressure finally exerted on the symphysis pubis. By this means fluid is expressed into the posterior urethra and then past the compressor urethræ into the anterior urethra, whence it can be obtained for purposes of microscopical examination. Prostatic massage should be carried out every fourth or fifth day.

The Prostatic Fluid. Normal prostatic fluid is faintly opalescent and of homogeneous character (fig. 2697). In inflammation of the prostate it may be opaque and turbid, granular, or definitely yellow and purulent. It is sometimes found that what appears to be normal macroscopically may on microscopical examination show many pus cells in the field. It is therefore essential to make a microscopic examination of the fluid, as the finding of pus cells—more than two or three to a field—means that the prostate is inflamed and treatment is necessary to effect a cure. If, in these mild cases, diagnosis is made by palpation only, the prostatitis may be missed and necessary treatment omitted.

Latent Posterior Gonococcal Infection (Type 4).

In Type 4 the infection appears to be anterior by the tests that have been applied, but after three weeks' anterior irrigation the discharge still persists and no anterior complications are found on examination. The urine has always remained free from a purulent haze, though occasionally there may have been a slight haze, disappearing after a

few hours. In the large majority of such cases the posterior infection spreads to the prostate and seminal vesicles via the lymphatics and not by surface contact along the urethral mucous membrane.

Acute Anterior and Posterior Infection—Mild (Type 5).

In this type, usually after one to two weeks, the infection becomes posterior. This occurs in 80 per cent of all acute infections. The patient may have no symptoms, or he may complain of slight pain at the end of micturition, with a feeling of fulness in the perineum or rectum. The prostate and seminal vesicles are always involved to a greater or lesser degree in all posterior infections, but on palpation they may show only very slight change.

In the treatment of both these types, anterior irrigation is carried on till the fourth week, at which time posterior irrigation is started. If

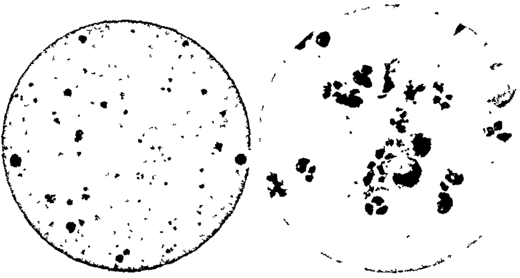


Fig. 2897.—Normal and purulent prostatic fluid.
(From Kidd's "Common Infections of the Male Urethra," Longmans.)

the prostate and seminal vesicles show no acute signs of inflammation, prostatic massage is started in the fifth week. In such cases the urine clears steadily, and the haze disappears after two weeks' posterior irrigation. By the ninth or tenth week a cure should have been effected.

Acute Anterior and Posterior Infection—Severe, with Complications (Type 6).

In this type the posterior infection increases in severity, the haze in the urine persists, and the prostate and seminal vesicles steadily become more swollen and harder. There is pyrexia, and the patient complains of severe pain (sometimes of blood) at the end of micturition, with frequency and a feeling of great discomfort in the perineum and rectum. If the patient goes to bed and is treated on the lines to be

ment has been by means of: (1) the radiant heat bath; (2) diathermy; and (3) short wireless waves, or inductothermy. The treatment by electropyrexia is carried out in two ways, one by means of the Kettering hypertherm—an air-conditioned cabinet in which the humidity can be controlled, and the other by means of a combination of general hyperpyrexia with local applications of the diathermy current to the pelvic focus of infection. The work of Desjardins, Stuhler and Popp, over the last two years on a series of cases treated with the Kettering hypertherm, shows very favourable results, and the rapidity with which gonococci disappear from the discharges and the purulent secretions themselves subside with this form of treatment is remarkable, most of the patients requiring only six sessions of fever therapy, two days' interval being allowed between each session.

In the second type of treatment—the combined treatment—Bierman and Levenson report very favourable results. In this the patient is placed in a warm bath at a 100° to 102° F. and the temperature is gradually raised to 108° F. By this means the rectal temperature is brought up to 105° F., after which pyrexia of this temperature is kept up for about 6 hours by transference to a bed covered with a hood made of insulating material and containing a battery of 60-watt electric light bulbs. The additional pelvic heating is carried out by the diathermy current, the active electrode being inserted into the rectum or vagina. In this way a treatment at 111° F. can be maintained in the pelvis for as long as 3 to 4 hours. In women the average number of treatments required for cure was about 2 and in men 3, the intervals between the treatments being 2 to 13 days.

It seems from these results that an organised attempt at investigation on these lines of treatment should be carried out in this country.

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CHAPTER II

Investigation and Treatment of Chronic Gleet

There is no sharp dividing line between the acute and the chronic stages of the disease, though it is safe to say that any acute gonococcal infection which has not been completely cured in three months should be considered as chronic.

Differentiation between a chronic and an acute case is rather difficult at times, as an exacerbation of a chronic infection may simulate a recent acute infection. It is only by a careful history-taking and a thorough examination of both the anterior and the posterior urethra that a positive diagnosis can be made.

There are two types of chronic gonorrhœa: (1) The persistent morning discharge, which may increase at times from consumption of alcohol, sexual excitement, etc.; and (2) the relapsing, yellow-discharge type, with quiescent intervals between the attacks. The large majority of cases of chronic gonorrhœa are due to infected seminal vesicles, the remaining cases being, as a rule, due to encysted abscess of the prostate or peri-urethral infiltration. The patient will give a history of persistent morning discharge or of acute attacks of fresh discharge. In addition, there may be a history of pain in the perineum, rectum and lower lumbar region, in the inguinal area, the lower part of the iliac fossæ and in the testicle. He may also complain of pain on ejaculation, and there may be a history of attacks of acute epididymitis, arthritis, or iritis.

Examination.

In examination of a chronic case the patient should be instructed, following suspension of treatment and the taking of a provocative dose of alcohol, to hold urine overnight or for at least six hours. Before he micturates, the urinary meatus is examined and the urethra milked forward from the bulb. A film culture is made from any discharge which may have been expressed. After the urethra has been washed out with oxycyanide of mercury, the patient then passes urine. This may be clear, or clear with threads. The threads are either sinking yellow purulent threads (pus), tiny " comma " threads (plugs from the prostate), or small glycerine-like floating threads (epithelial cells and

mucus). The urine may show a purulent haze which is due to a vesiculitis, prostatitis, cystitis or pyelitis.

The patient is then examined in the knee-elbow position, and the condition of the prostate and seminal vesicles noted, prostatic massage being given, and the resulting secretion taken for cultures and films. The testicles are examined for any sign of epididymitis. Urethroscopic examination then follows.

Posterior urethroscopy (see Volume II, page 2708) may reveal a polyp or cyst of the posterior urethra. In some 20 per cent of cases the root of the trouble is in the anterior urethra, and examination by the urethroscope may show conditions already described, with, in addition, an intermediate stricture, hard stricture, polypi, "millet seeds" (small grey masses of lymphoid tissue in the anterior urethra), or leukoplakia.

Treatment.

The general measures are similar to those given in Chapter I, but in resistant cases vaccines and protein shock must be considered. It is in chronic cases that pyridium by the mouth gives the best results.

Chronic Anterior Infections. Treatment of infected glands of Littré and lacunæ of Morgagni, peri-urethral infiltrations and soft infiltrations has already been described. The treatment of intermediate and hard stricture is described in Volume II, page 3074. Polypi are treated through the urethroscope, a probe coated with silver nitrate being applied and the base destroyed. For "millet seeds", dilatation with the anterior straight irrigating Kollmann is followed by painting of the whole urethra with silver nitrate solution (5–20 grs. to the ounce) at intervals of a week.

Chronic Posterior Infections. The treatment consists of prostatic massage, dilatations, posterior irrigations, and instillations. A large majority of cases will get well by means of the method described in Chapter I—that is, the filling up of the bladder with 1 in 6000 oxycyanide of mercury, the passage of curved steel bougies (English scale from 12–13 up to 15–18 if possible), and massage of the prostate after removal of the bougie.

Instillations. In most cases it may be advisable, in addition to the use of dilatation and prostatic massage, to employ instillations, an interval of four to five days being given between each treatment. The instillation treatment involves the following technique:

After the prostate has been massaged and the patient has urinated, an Ultzmann catheter is passed (see fig. 2898), and half a drachm of silver nitrate—starting with 5 grs. and working up to 20 grs. to the ounce—

is instilled into the posterior urethra. Instead of the Ultzmann syringe, a Guyon catheter or syringe may be used (fig. 2899). In the Ultzmann technique, when the catheter is depressed the point lies on the posterior urethra. The patient will feel a burning sensation in the perineum, extending backwards to the rectum and forwards to the meatus, and will experience an urgent desire to pass urine. He should not, however, do so for at least fifteen minutes, if possible. When the Guyon

Fig 2898.—Ultzmann catheter and syringe.

catheter is used, the compressor urethræ is felt to grip the instrument as it passes. The instillation is made into the posterior urethra after the catheter has been moved an inch beyond this point.

In very resistant cases—especially those with encysted abscess and occluded vesicle—when other methods have failed I have given the following treatment: The bladder being first filled up with oxycyanide of mercury, a bougie of 14–17 or 15–18 English scale is passed It is kept in, well depressed in the perineum, for

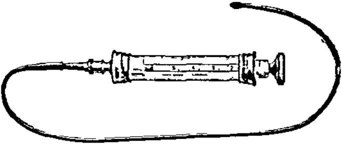

Fig 2899.—Guyon catheter.

five minutes. After removal, prostatic massage is given with the patient bending forward touching his toes. He then urinates, and immediately afterwards an instillation of silver nitrate is made.

Suction treatment is also worth trying in some resistant cases. The bladder being filled with oxycyanide of mercury, a curved metal catheter the same length as the Ultzmann with fenestrations to a length of about one inch at the tip, is then passed and depressed, suction being made with a bulb (see fig. 2895).

If all these measures fail, the operations of vasopuncture, vasostomy, catheterisation of the ejaculatory ducts, vesiculectomy, or drainage of prostatic abscess by a perineal operation must be considered (see Volume II, Part XI).

Results of Treatment.

It is very rarely that chronic posterior infections will not clear up with the treatment I have described—massage, dilatation and instilla-

tions. In my experience dilatation by curved steel bougies is the most essential treatment. They may be used even up to 15–18 English scale, so long as they do not produce tearing of the urethra. The bougie should be left in for five or even ten minutes if possible. I have had cases in which massage only has been given which have persisted for eight years; but when one or two dilatations have been given, a large mass of debris resembling seaweed is passed out in the oxycyanide of mercury (sometimes reaching a depth of 2 inches in a conical urine glass). This means a free drainage of a chronic occluded vesicle, and the patient may really be cured at last by this one treatment.

In the treatment of resistant posterior cases the following are the favourable signs: (1) The seminal vesicles become softer, less tense, and less cystic, the prostate becoming smaller and the scattered hard areas less numerous; (2) a large amount of debris passes after dilatation and massage; (3) a profuse discharge of pus, and occasionally of blood, occurs within twelve hours of dilatation and massage, the discharge and blood lasting for several days, and the urine showing a deep purulent haze and then suddenly becoming transparent; (4) the urine which has shown a persistent haze, sometimes so fine that it can only be recognised as a fine dust in a good light, becomes *absolutely* transparent; and (5) a mild persistent tenderness low down in the iliac fossa, in the region of the inguinal canal, or in the globus minor of the epididymis disappears.

Criterion of Cure.

The determination of cure in a chronic case is a much more difficult problem than in that of an acute case. In the chronic condition the infection may be latent for many months, and in such cases an examination even of an all-night retention of urine may reveal only urethral secretion showing squamous cells with a few pus cells and no cocci. Cultures and films may be negative, even though alcohol has been taken and all treatment suspended for some weeks. In such latent cases a most careful examination must be made for a chronic vesiculitis or peri-urethral infiltrations ("peas"). These are the lesions which may escape detection and cause the patient to be passed as cured. This fluid may be expressed from a prostate which passes the test, but on rectal examination a swelling may be felt, in some cases indefinite and in others distinctly hard and localised, in the region of the prostate or seminal vesicles. In all probability nothing has been expressed from this area, while all the time it may hold a collection of pus containing gonococci. In cases where any such condition is made out on palpation, the patient should be under observation for six months before being pronounced cured, a large bougie being passed every

fourteen or twenty-eight days, and the patient subjected to a urinary and prostatic fluid examination twenty-four hours afterwards. If no relapse occurs in the course of these treatments, then these hard areas may be regarded as being due to scar tissue and the patient deemed free from infection.

Another valuable test-method is as follows: The prostate and seminal vesicles are massaged after the patient has micturated, no posterior irrigation with any antiseptic being given. The patient then takes alcohol and is examined twenty-four or forty-eight hours later. I have on several occasions found that an acute (anterior) urethritis showing gonococci followed in a day or two the expression of prostatic fluid from the posterior urethra. In only a small number of cases where the seminal vesicles are unduly relaxed or are tense with semen can seminal fluid be massaged out at all. It is the palpation of the seminal vesicles for occlusion that is really the most important criterion of cure. The prostatic fluid can be expressed without difficulty, and the material obtained for films and cultures—an accurate test—is much easier in such cases.

Semen Examination. This method is used largely in France. The microscopic examination of semen is less productive of results than cultures made from it for the presence of spermatozoa. and mucus in the sperm tends to obscure the microscopic field. The examination comprises: (1) The patient, after retaining urine all night, ejaculates into a sterile test-tube, and cultures and films are made from this material; (2) the urethra is irrigated with silver nitrate, urine is voided into a sterile vessel. and the sperm is collected in the usual way and subjected to microscopical and cultural examination; and (3) if on examination the semen is more purulent than the prostatic secretion, this is evidence of a vesiculitis. On the previous night an instillation of silver nitrate is made into the posterior urethra. Prostatic massage is performed on the following morning. after which the patient ejaculates into a sterile tube.

The Complement Fixation Test, for a complete account of which readers are referred to the excellent monograph by Dr. L. N. Orpwood Price (L.C.C. Reports, Sept. 1933), demonstrates the presence or absence of specific gonococcal anti-bodies in the blood, and thus does not necessarily signify the presence or absence of gonococci in the tissues. Reactions vary from "negative," through "weak positive," "positive," and "strongly positive," to "very strongly positive." The test is of special value in indicating the probable presence of a "closed" infection (seminal vesicles or Fallopian tubes) and in determining whether the cause of, say, arthritis or iritis is gonococcal or not.

A strongly positive test usually indicates an active infection—posterior

urethritis in the male and cervical or tubal complications in the female. A positive result may mean acute or chronic gonorrhœa. A weakly positive test may be obtained in an early case (say, three weeks after infection), in a sub-acute case limited to the anterior urethra, or in an old-standing case approaching final cure. A negative test, with gonococci demonstrated in the secretions, may mean an early acute infection of less than 21 days' duration, an anterior urethritis (male) or lower genital infection (female), or a seminal vesicle or prostatic infection yielding to treatment. A negative test in the absence of gonococci implies either no gonococcal infection, or cure.

In assessing the criterion of cure, both clinical and pathological evidence must also be taken into consideration, and no patient should be discharged as cured on the strength of a single negative Complement Fixation Test.

A positive Complement Fixation Test has no value whatever if gonococcal vaccines have been given for some months prior to the test.

The tests by *irrigation of the anterior and posterior urethra* with silver nitrate and the gonococcal vaccine provocative tests have been given up as a routine measure for some time, and cannot be regarded as satisfactory.

CHAPTER III

TREATMENT OF COMPLICATIONS

THE complications of gonorrhœa may be divided into three main headings according as the infection undergoes:

(1) Local extension:

(a) To areas *not* opening into the urinary tract.

(b) To areas communicating with the urinary tract.

(2) Mechanical transference to other mucous membranes.

(3) Blood-stream dissemination (gonococci or toxins).

LOCAL EXTENSION

(a) Under this classification the "areas *not* opening into the urinary tract" comprise the lymphatic system only.

Adenitis. In cases where the patient has to walk much or do heavy manual labour, there is frequently swelling and tenderness of the sub-inguinal glands. This may, unless the patient rests, proceed to suppuration which, however, is very rare.

Lymphangitis. A definite, hard, tender dorsal lymphatic of the penis may be felt. This occurs in cases where there is a marked œdema of the meatus and prepuce with balanitis, and is sometimes seen when high-pressure anterior irrigation is used in acute cases. An inflamed dorsal lymphatic which seems cartilaginous on palpation is always suggestive of a primary syphilitic lesion, which may be found just inside the urinary meatus and may be so small that it is missed. Rarely, small abscesses of the penis may arise from local infection by gonococcal pus or be secondary to lymphangitis.

(b) The male urethra shows a large number of openings branching off from the urethra throughout its whole length, and few cases of gonorrhœa are not complicated by their infection. The areas that may be involved in this way are: (i) Para-urethral follicles and parts in association with the preputial sac; (ii) Littré's ducts and glands and the lacuna magna; (iii) Cowper's ducts and glands; (iv) the sub-urethral tissue of the urethral tract; (v) the prostatic ducts and glands; (vi) the seminal vesicles; (vii) the ejaculatory ducts, the vasa deferentia and the epididymes; and (viii) the bladder and the upper urinary tract.

Para-urethral follicles, Littré's glands, and preputial structures.

The first two items under this heading have already been dealt with (Chapter I). Local complications may occur in a sub-acute, acute, or chronic urethritis.

The preputial sac, being covered with squamous epithelium, is not easily infected, though it is not immune if the parts are not kept very clean, especially if there is some degree of phimosis and local moisture. At times two small ducts, the lateral frenal glands of Tyson, may become inflamed and a localised swelling may occur on one or both sides of the frenum. In the event of an abscess, the glands must be opened and the cavity cauterised. If the prepuce can be retracted, general cleanliness and sub-preputial irrigation with 1 in 5000 hydrarg. perchlor. or applications of 10 per cent picric acid in spirit to the glans penis will rapidly clear up balanitis. A long prepuce which cannot be properly retracted may require complete circumcision, but if there is much swelling hot baths and sub-preputial irrigations with hydrarg. perchlor. or 1 in 1000 eusol may in time make complete or modified circumcision possible. Ulceration of the glans penis demands slitting of the dorsum of the prepuce or the removal of a V-shaped wedge. When the glans penis has been exposed and thorough cleansing carried out, the ulceration will rapidly clear up, and a circumcision can be performed later. An abscess on Tyson's glands must be opened and the cavity cauterised. Occasionally it may be necessary to dissect out the gland and duct.

Inflammations of Cowper's Ducts and Glands.

The left Cowper's gland, which opens further forward than the right, is the one more often infected, though this is not a frequent complication. The symptoms are pain in the perineum, especially on rising or sitting down, and occasionally pain on defæcation. Urethritis accompanied by a palpable swelling in the perineum arouses suspicion, and palpation of the gland with the forefinger in the rectum and the thumb placed on each side in turn of the mid-line of the perineum secures a certain diagnosis of Cowperitis and a differentiation from sub-urethral infiltration of the floor of the bulb. If the duct is permeable, a course of massage of the gland with posterior irrigation and subsequent dilatation with steel bougies will cure the condition. Occlusion of the duct may result in an abscess, necessitating suspension of all local urethral treatment. The patient is kept in bed, hot baths are given, and hot fomentations applied. If fluctuation is elicited, an incision should be made in the perineum, but before this is done the urethra should be irrigated and a straight bougie passed to localise

the point of the abscess. Excision may be required for an indolent inflammation.

Sub-epithelial Disease of the Urethral Tract.

Soft infiltrations and hard strictures have already been mentioned.

Inflammation of the Prostatic Gland and Ducts.

Inflamed prostatic ducts occur in every case of posterior gonococcal urethritis. If the ducts only are involved—which is rare—it is difficult to distinguish the condition from posterior urethritis, but the gland itself is nearly always affected, and acute, sub-acute or chronic prostatitis supervenes. In some cases an abscess may form in the acute stage; but in others the condition remains sub-acute from the beginning, giving rise to only slight symptoms, the prostatic inflammation always tending to subside and to pass on to a chronic state.

Acute Prostatitis. This is rare before the second or third week of the disease. The symptoms are frequently an urgency of micturition, pain at the end of the act, pain in the perineum, hypogastrium and rectum, and pyrexia of 101° to 103° F. The diagnosis rests on signs of posterior urethritis. On rectal examination the prostate is enlarged in one or both lobes, and is tender, with areas of softening amidst small, hard, nodular swellings. The treatment consists of rest in bed and the measures described in Chapter I of this section.

Prostatic Abscess. Acute prostatitis may proceed to prostatic abscess. The symptoms comprise rigors, and pyrexia occasionally to 103° to 104° F. All symptoms are more severe in cases of abscess, and there may be complete retention of urine with diminution or cessation of the urethral discharge. On rectal examination the prostate is felt as a tender, tense, globular swelling bulging into the rectum, and fluctuation may be made out by manual examination. An acute gonococcal prostatic abscess is quite different from the more common—and more serious—non-specific prostatic abscess. Gonococcal abscess rarely requires incision and drainage. In acute prostatitis the prostate is smaller and less tender; in prostatic abscess the symptoms are considerably more severe, and the gland is much more tender, and often asymmetrical. The treatment is the same as for acute prostatitis, though it may be necessary to deal with retention of urine. The abscess usually bursts in forty-eight hours, most frequently into the urethra, rarely into the rectum, and more rarely still into the peri-prostatic tissue where it causes a pelvic cellulitis.

Gonococcal proctitis seldom follows bursting into the rectum. There is a copious discharge of pus, mucus, blood and fæcal matter, which gives instant relief, and all that is found on examination is a

tiny dimple in the anterior wall of the rectum, which in time closes, leaving no ill-effects. In pelvic cellulitis the diagnosis is made by rectal examination, the finger feeling a mass of soft, boggy, inflammatory œdema surrounding the prostate and seminal vesicles and obliterating their outlines. The rectum is filled more or less completely with this boggy mass, and may show signs of fluctuation.

If the abscess does not burst of itself within two or three days, operation is required. A rectal incision is not advisable, and it is necessary to operate by the perineal route 1 inch in front of the anus.

Chronic Prostatitis. (See Chapter II.)

Inflammation of the Seminal Vesicles.

In the large majority of cases of infection of the prostate, the seminal vesicles also are involved, the infection from the posterior urethra reaching them via the ejaculatory vesicular ducts. Infiltration of the walls of the vesicles and of the peri-vesicular tissue is the rule. The seminal duct often becomes occluded, resulting in a closed-in pus sac. In the acute stages the occlusion of the duct is due to œdema; in the chronic stage it results from the formation of fibrous tissue round the duct. This occlusion makes the cure of chronic vesiculitis very difficult. Acute vesiculitis usually occurs in the second or third week of the disease; the symptoms are similar to those of acute prostatitis, but terminal hæmaturia, painful erections and painful seminal emissions are more common.

Diagnosis rests on signs of a posterior urethritis, as shown by tests, and on rectal examination which reveals a tender, tense, swollen vesicle.

Treatment is the same as for acute prostatitis, posterior irrigation and prostatic massage being started when the acute symptoms have subsided.

Inflammation of the Ejaculatory Ducts, Vasa Deferentia and Epididymes.

Epididymitis occurs in 10 to 15 per cent of all cases of gonorrhœa, and sterility is said to be found in from 25 to 40 per cent of such cases.

The infection from the posterior urethra is carried either by the lymphatics by continuity of the surface, or by the urine.

Pelouze considers that the infection passing along the lymphatics of the vas deferens or through continuity of a long narrow mucous channel is rare, this being supported by his observation that the epididymis is inflamed before the vas deferens in over 90 per cent of his cases. He considers that the gonococcus when spreading in such a way would have to pass a distance of 47 cms. against the current of fluid and the peristalsis of the vas, it being difficult to postulate reversed peristalsis when one considers the anatomy of the ejaculatory duct. In favour of the spread of the gonococcus-laden pus reaching the epididymis by the transference of the gonococcus or the gonotoxin is the observation of Belfield that,

when he opens the vas deferens near the inguinal canal in his operation of vasostomy, a few drops of urine ooze from the opening when the bladder is full, that in many patients when the bladder is quite full the internal sphincter relaxes and the posterior urethra virtually becomes a part of the bladder cavity, and that the ejaculatory ducts are frequently patulous in some individuals, as evidenced by the presence of spermatozoa in their morning urine in the absence of an orgasm.

Epididymitis very rarely occurs without involvement of the seminal vesicle of the same side. Predisposing causes are the same as in inflammation of the prostate and seminal vesicles, and, according to Pelouze's observations, a full bladder must be an added factor. The condition usually occurs in the second week of the disease. It is often ushered in by pain in the groin extending up to the iliac fossa, and on the right side it may simulate acute appendicitis. As the pain increases and radiates more to the scrotum, the urethral discharge often lessens. There is a pyrexia of usually 102° to 104° F., and there is evidence of posterior urethritis. Examination reveals the globus minor of the epididymis as tense, tender and swollen. The skin over this part of the scrotum is red and tender, and often there is a small acute hydrocele. The pain may be intense, and as the inflammation of the epididymis extends up to the globus major, involving the posterior part of the body of the testicle, and as the hydrocele increases, the whole scrotum becomes filled with inflamed products and assumes a very large size. The inflammation is usually unilateral, though both epididymes may be affected.

Differential diagnosis is from B. coli epididymo-orchitis and acute tuberculous epididymitis In gonorrhœa there is evidence of a posterior urethritis and vesiculitis, with gonococci found in the urethral discharge. The globus minor is involved first and infection spreads upwards to the globus major. In tuberculosis the pain and tenderness are usually less acute, and there is abscess formation. Tuberculous lesions are present in the prostate, the seminal vesicle, the opposite epididymis, or the kidney. The discharge, if present, is watery and may contain tubercle bacilli, and urethral symptoms are very slight.

Treatment. Rest, hot baths, with elevation of the testicles which should be covered, and a cradle for the bed-clothes are indicated. The application of hot-water bottles or antiphlogistine to the testicles is useful, as is also diathermy. Hot saline enemata, two pints at 115° to 130° F., may be given twice daily. Atropine suppositories and daily intravenous injections of 10 cc. of a 10 per cent calcium gluconate often hasten a cure.

Surgical treatment has been recommended, but in my experience it is never indicated unless an abscess forms, which is very rare and is due to a mixed infection. The operative procedures that have been tried are: (1) puncture of the globus

minor with a large-bore needle, followed by aspiration; and (2) an incision about two inches long into the postero-lateral aspect of the scrotum, this being carried down to the tunica vaginalis, which is opened over the entire length of the epididymis. The epididymis is then exposed and punctured, the wound being washed out with saline and a drain inserted.

Inflammation of the Bladder, Ureters and Kidneys.

Gonococcal cystitis is a rare condition, the bladder mucous membrane not being a suitable medium for the implantation of gonococci. It used to be held that gonococcal cystitis was always the result of a mixed infection, but Young and Wertheim have proved the fallacy of this supposition.

Trigonitis is much more common than cystitis, and is probably found in nearly every case of acute posterior urethritis. The symptoms of this condition are those of acute posterior urethritis, that is, pain, frequency and urgency of micturition, and tenderness and pain in the suprapubic region. Pus in all three glasses suggests an inflammation of the bladder. Usually there is a secondary infection, coliform bacilli being the most common. Rest in bed on a light diet, purgation, hot baths, heat applied to the suprapubic region, atropine suppositories, and an alkaline mixture of potassium citrate or elixir saw palmetto et santal form the best treatment. Later, when the acute symptoms have subsided, posterior irrigations with 1 in 8000 potassium permanganate or, if the infection is mixed, 1 in 6000 oxycyanide of mercury, 1 in 6000 acriflavine, or 1 in 1000 albargin can be used.

Chronic cystitis. This is met with as a secondary infection following gonorrhœa. It usually arises as the result of long continued treatment with the passage of imperfectly sterilised instruments. In some cases the bladder has been washed out over a long period by the patient himself, using a rubber catheter with a syringe attached.

Cases showing a persistent haze in all three glasses over a long period following gonorrhœa should always be carefully examined so as to exclude any serious condition of the bladder or kidneys.

Ureters and kidneys. Pure gonococcal infection of the kidneys is very rare, and only forty cases have been reported. Mixed infections are more common, staphylococci and streptococci, tubercle and typhoid bacilli being found in conjunction with the gonococcus. The infection may be hæmatogenous, as in gonococcal septicæmia; lymphatic, via the lymphatics of the urethra; or ascending, a urethritis being present and the spread occurring by continuity. Sub-acute and chronic infections are more common than acute. There is usually pain in the back and loins and in the kidney angle, pain at the

end of micturition, and perhaps a terminal hæmaturia with some frequency of micturition. Pyrexia of 100° to 101° F. is not uncommon, and the patient feels altogether worse than he would in the presence of a lower urinary tract general infection. Urine in all three glasses is loaded with pus and renal epithelium, though the pyuria may be intermittent. An accurate diagnosis of general infection of the urethra and kidney is difficult. Cystoscopy and ureteric catheterisation are required, and films and cultures should be made of the centrifugalised urine.

The treatment consists of rest in bed on a light diet, purgation, and the use of urinary antiseptics. It is essential that treatment of the lower urinary tract should be carried out before any attempt is made to deal with the kidney and ureters. Any urethral stricture must be treated. Renal lavage and drainage of the kidney pelvis by operation, or nephrectomy, may be required later.

Perinephritis. This is very rare.

MECHANICAL TRANSFERENCE TO OTHER MUCOUS MEMBRANES

Infected material may be carried to other mucous membranes such as the conjunctiva, or the mucous membrane of the mouth, nose, anus or rectum.

Conjunctiva.

Gonococcal conjunctivitis in the adult nearly always results from auto-infection but it may be caused by contamination from virulent gonococcal-bearing material from another person. The disease is generally seen only among infants, and the Credé prophylaxis makes it uncommon here. Considering the great incidence of gonorrhœa amongst adults, the number of cases of conjunctivitis seen—even among patients whose personal hygiene may not be of a high standard—is so few that it would appear that the adult conjunctiva possesses an immunity to the infection.

The symptoms, prognosis and treatment are described in the article on Diseases of the Eye (see page 4527).

Buccal and Nasal Mucous Membrane.

The mouth, being lined by a squamous epithelium, affords poor soil for the gonococci, but the absence of a horny layer may favour infection. The infection, rare at any time, occurs more often in infants—the mucous membrane being thin—and is associated with a gonococcal ophthalmia. The incubation period is two to three days. The severity and infection vary greatly, septicæmia being not unknown. In children it is usually very mild, the bleeding yellowish elevations on

the roof of the mouth and anterior part of the tongue clearing up in a few weeks.

In adults, the condition is usually much more severe. On examination the mucous membrane shows red soft granular patches, generally on the posterior part of the tongue. The gums are spongy, with ulcers covered by a yellowish-white membrane. Gonococci are found in the pus. In infants, mild treatment with boro-glycerine, potassium chlorate and sodium bi-borate suffices. In adults, gargles, mouth-washes of hydrogen peroxide, and applications of silver nitrate and chromic acid to the ulcers are indicated. Steps should be taken to prevent spread of the infection to the eyes.

Nose. This complication is very rare, and it is doubtful if any case in an adult has ever been proved by thorough bacteriological examination. In infants it seems to have been definitely established that the disease is contracted at birth from the gonococcal infection in the generative organs of the mother.

Anus and rectum. Contrary to expectation, anal infection with the gonococcus is rare in women. Rectal gonorrhœa may result indirectly from a gonococcal focus in the neighbourhood of the anus. In men rupture of a prostatic abscess into the rectum seldom leads to gonococcal proctitis. The infection may also be carried by contamination with enema nozzles or other instruments, or by digital infection. Most commonly gonococcal proctitis is the result of unnatural practices.

There are two types of infection: the acute and the indolent.

Acute Proctitis. This is the type less commonly seen. The patient complains of heat, itching, and a feeling of fulness about the anus and lower rectum, accompanied by severe pain during defæcation, and there may be tenesmus and moderate pyrexia. Pus is seen oozing from the anus, and there is erythema of the peri-anal region, sometimes extending to the thighs, perineum and buttocks.

Indolent Proctitis. The indolent type is characterised by the absence of objective symptoms. There is no pain, and the patients are only aware of the condition because they fear they have been infected, and therefore they examine their stools and look for a slight thin discharge that may be present in this type of case.

On examination the anus will often be funnel-shaped, and the sphincter markedly weak and patulous. At the posterior end of the anus a narrow, superficial fissure is often seen, and there is frequently a single, elongated, soft, painless polyp. No pus may be noticed until the rectal speculum is introduced, when a thin brownish discharge may be detected. Only with the utmost difficulty can the

gonococcus be found amongst the large number of micro-organisms present.

Complications. These are: (1) Acute peri-rectitis, associated with a secondary infection by coliform bacilli: (2) chronic peri-rectitis, resulting in a firm, hard infiltration around the rectal walls which bulges into the rectum itself, (3) stricture of the rectum, usually regarded as the most frequent sequela: (4) a proliferative condition of the perineum in which there are sessile and pedunculated polypoid growths; and (5) multiple fissures about the anus.

Treatment. In the acute type the patient should be confined to bed and the bowels kept open with gentle laxatives. Frequent washing of the peri-anal region is followed, after drying, by powdering with dermatol or zinc oxide and starch. Hot sitz-baths are useful, but instrumentation and digital examination are practically impossible without an anæsthetic, and the local treatment resolves itself into douching twice daily with two pints of sterile water containing sodium bicarbonate 2 drachms, and later with 1 in 8000 potassium permanganate, 1 in 1000 albargin or 2 per cent aqueous mercurochrome. In some cases this course of treatment will cure the infection in about a month, especially in the absence of hæmorrhoids, fissures and fistulæ.

If, however, the case is of the chronic type and is not cured in four weeks by this method, further treatment through a proctoscope is required. The bowels should be emptied an hour before the examination, and a saline irrigation should precede the passing of the proctoscope. The patient lies on his back with the pelvis raised and the legs well apart (though he may be examined lying on his left side). The instrument, well lubricated, should be passed with the greatest gentleness. Local applications of silver nitrate solution 5 grs. to 2 ounces, or other silver salts such as neoreargon 5 per cent, lunosol 10 per cent, or neoprotosil 10 per cent can be applied to the rectal wall every fourth or fifth day, irrigation with potassium permanganate being given on the other days. In some cases when local application to the rectum cannot be carried out, suppositories of argyrol or protargol 5 per cent are inserted every night as a supplement to the daily irrigation.

BLOOD-STREAM DISSEMINATION

In the general systemic infection the gonococcus may be disseminated in one of two ways: (1) Through the blood stream; or (2) through the lymphatics, the first being the commoner route. There is probably always some trauma of the mucous membrane whereby the gonococcus gains entry to the circulation. The predisposing causes to

a systemic infection are heavy exercise, trauma, unskilful instrumentation, alcoholism, and general constitutional disease. Metastatic lesions are merely local manifestations of a general infection.

In describing all the complications of gonorrhœa which are due to general dissemination of the gonococcus or its toxin it is best to divide them into two clinical types: (1) *Gonococcal septicæmia*; and (2) *metastatic complications*, sub-divided into (*a*) *common manifestations*, affecting the joints and structures in connection with them, such as ligaments, bursæ, periosteum and muscles; (*b*) *less common manifestations*, affecting the conjunctiva, iris, choroid and optic nerve; and (*c*) *rare manifestations*, affecting the pericardium, endocardium, pleura, brain and central nervous system.

Gonococcal Septicæmia.

Systemic infection may occur in any case of gonorrhœa, usually during the chronic stage of the infection. Mixed infections are not uncommon, the other organisms being B.coli, streptococci and staphylococci. Gonococcal septicæmia as a clinical entity is very rare, the primary focus being almost always in the prostate or seminal vesicles. The symptoms are those of any other septicæmia produced by pyogenic organisms. Diagnosis depends entirely upon the demonstration of gonococci in the blood stream. Treatment is directed to the primary focus and to the general condition. The prognosis depends upon the presence or absence of gonococcal endocarditis, embolic phenomena, and sudden alteration in the heart sounds.

Common Metastatic Complications—Arthritis and allied conditions.

In metastatic infection in the male the primary focus is almost always *in the prostate or seminal vesicles, and an occluded vesicle is the commonest cause. In women the urethra, cervix,* and, less commonly, Bartholin's glands are the sites of the primary focus. Ophthalmia neonatorum has been reported as a primary focus. Arthritis is said to be four times more common in the male than in the female. It is rare for the gonococcus to be found in the metastatic lesion, and for this reason some hold that the lesion is due to a gonotoxin. It is probable that the difficulty in demonstrating the gonococcus in the joint fluid is that it remains limited to the synovial membrane, as in a tuberculous cold abscess. To find the organism the joint must be aspirated within the first two or three days following its infection.

Onset of Arthritis. The infection may occur within a few days of the onset of an attack of gonorrhœa. Usually it occurs in the third or fourth week, though there may be an interval of many years after the initial attack. The infection may be mono- or poly-articular, the latter

being the more common, except in chronic urethral infection. The larger joints are involved more frequently than the smaller, and the usual order of incidence is: knee, ankle, wrist, fingers, metatarso-phalangeal and metacarpo-phalangeal joints, elbow, shoulder, hip, and, rarely, the intervertebral, temporo-mandibular and sterno-clavicular joints. The clinical types may be divided into acute, sub-acute, and chronic.

Acute Arthritis. This is sub-divided into four types: (*a*) Arthralgia, in which one or more joints may be painful, but there are no gross physical signs of disease. (*b*) An acute infection of one or more joints, usually the larger ones, in which the inflammation is mostly synovial with considerable effusion into the joint. (There may sometimes be œdema and redness of the skin, showing involvement of the capsule and peri-articular structures.) (*c*) An acute infection involving the synovial membrane and articular cartilage, and causing a sero-fibrinous exudate. The capsule and peri-articular structures are always affected, as is shown by local œdema and redness. (When the smaller joints are the seat of the infection, the peri-articular inflammation is often very marked, leading later to adhesions and subsequent deformity; with much destruction of the cartilage, as in the larger joints, there may be subluxation of the joint and gross deformity.) (*d*) An acute purulent infection of the synovial membrane and articular surfaces, involving great destruction of the cartilage and a frank exudate (pyo-arthrosis). This occurs in the large joints, and is very rare. There is usually a mixed infection, but it may be associated with gonococci in pure culture.

Sub-acute and Chronic Arthritis. There are three types: (*a*) Hydrarthrosis, usually seen in the knee joint, involves a thickening of the synovial membrane and often a large effusion, inflammation of the peri-articular structures being rare; this may arise as a sub-acute type, or may follow an acute synovitis. (*b*) Synovial, articular and peri-articular involvement, poly-articular in distribution and usually affecting the small joints, leads to much deformity and may follow an acute infection or be sub-acute from the onset. (*c*) Spondylitis (ankylopoietic type) is found between the ages of twenty and fifty, and is much commoner in males. There is osteoporosis of the vertebræ and pelvic bones, and ossification of ligaments and intervertebral discs, leading to ankylosis of the vertebræ and sacro-iliac and hip joints. The onset is gradual; the earliest symptom is pain either in the part of the back affected, or referred to the distribution of the peripheral nerves. The danger of this condition lies in the possibility of stiffness and even deformity if a bad position of trunk and limbs is maintained

for any length of time. The onset is gradual and the condition is usually progressive.

Symptoms and Diagnosis of Arthritis.

Arthralgia may be present in several joints, proceeding to a definite arthritis of one or more joints. Pain is very marked in the acute type, and pyrexia usually reaches 101° to 103° F. Both symptoms are intensified if there is suppuration, which, however, is very rare in the smaller joints. In the sub-acute cases synovial effusion is a marked feature, except in the smaller joints. There is marked wasting of the muscles, and the swelling of the joints presents a fusiform appearance. In untreated cases there may be marked limitation of movement from adhesions. The diagnosis of acute gonococcal arthritis is not difficult if a history of possible infection can be traced, and signs of the disease recognised, particularly in the prostate and seminal vesicles. Failure to demonstrate gonococci in aspirated fluid, and even a negative complement fixation test, does not exclude the possibility of infection. The test, which is positive in 75 per cent of cases, is of special value where genito-urinary examination is clinically suggestive and the joint condition obscure.

Differential Diagnosis. The conditions to be distinguished are acute rheumatism, tuberculous arthritis, infective arthritis (due to streptococcal and pneumococcal infections, dysentery, typhoid fever, scarlet fever, tonsillitis, and other focal septic conditions), and neuropathic arthritis (tabes dorsalis and syringomyelia).

In *acute rheumatism* there is no evidence of a focus in the genito-urinary tract; pyrexia and general prostration are more marked; acid sweating is pronounced; pain is more severe; many joints are involved and the inflammation flits from joint to joint; peri-articular tissues are not involved; cardiac complications are often present; while symptoms and pyrexia react to salicylates, and the C.F.T. is negative.

In *tuberculous arthritis* the onset is gradual, and there is again no evidence of a gonococcal focus in the genito-urinary tract. Muscle wasting around the joints is marked and there is epiphysial involvement. The severity of the pain is less than in gonococcal arthritis. Skiagrams show the osseous nature of the disease, there is evidence of tuberculosis in the other organs, the infection is generally mono-articular, and the Mantoux test is of value.

Secondary rheumatoid arthritis is usually polyarticular. There is a fusiform, white, doughy, tender swelling of the joints without marked pyrexia. An infective focus of the teeth, gums, tonsils, sinuses, or bowel can usually be found. The blood sedimentation rate is markedly increased. Though no gonococcal focus is found in the genito-urinary tract, there may be a streptococcal prostatitis and vesiculitis, with a history of acute gonorrhœa many years previously. Neuropathic joints are seen in tabes dorsalis and syringomyelia. In these there is a rapid painless disorganisation of the joint, and there should be no difficulty in recognising the cause.

Prognosis of Arthritis.

A prognosis of perfect restoration of function should be guarded in every case. In the majority of cases the outlook is good, even where there is some destruction of cartilage, if proper treatment of the joint and focus is started early and the patient co-operates. In pyo-arthrosis operation is usually required, and there is marked loss of function. In cases of great destruction of the articular cartilage there is usually a fair amount of limitation of movement and the prognosis should be very guarded.

Summary of Treatment.

The first and most important line of treatment consists in an attack on the original focus with the object of cutting off the supply of gonococci or their toxins. The second line of treatment is directed towards the infected joint, the most vital consideration being the prevention of adhesions. The third line of treatment deals with the blood infection, and, finally, the fourth concerns the general health of the patient.

Treatment of Focus. The focus in the male is always in the prostate and seminal vesicles—the anterior urethra may be disregarded. The treatment has been described in Chapters I and II. If the arthritis develops in the first few days, or before the fourth week of the initial infection, it is advisable to postpone posterior irrigation and prostatic massage until after the fourth week, the patient being treated by rest in bed, and a bland diet with a large amount of fluid. The prostate is treated with hot saline enemata and the urethra is given gentle anterior irrigation only. A vaccine may be useful (see Chapter IV).

Cases which prove resistant to the treatment already described may require surgical measures—catheterisation of the ejaculatory ducts, vasopuncture, vasostomy, or even vesiculectomy. It is rarely, however, that prostatic massage, dilatations, posterior irrigations, and instillations fail to effect a cure.

The injection of Pregl's solution (an aqueous isotonic iodine solution which liberates nascent iodine) via the rectum has given successful results in America. After an enema, the site is painted with mercurochrome, the patient is placed in the knee-elbow position, and, without a local anæsthetic, 5 cc. of Pregl's solution is injected into each lateral lobe of the prostate. This treatment is said to be of most use in acute cases, improvement being noticeable in the joints within twelve hours. A total of three or four injections is given over three weeks.

Treatment of Joints. In the acute cases in the early stages, rest and immobilisation of the joint is required. The limb should be kept between sand-bags, and where there is destruction of cartilage or a threat of pyo-arthrosis a light splint will be required. Radiant heat or

antiphlogistine is perhaps the best local application. Bier's treatment should always be given a trial.

As soon as the acute pain has passed off, active and passive movements and gentle massage of the joints should be started, and contractions of the muscles induced with a Morton Smart coil. Unless this treatment is begun early, adhesions will form.

In acute cases which do not respond to these measures, it may be advisable to aspirate the joint, this perhaps (but rarely) being followed by an irrigation, or the performance of arthrotomy with drainage. Aspiration is indicated where the joint fails to improve within four weeks, or shows subluxation. After aspiration, a saline wash-out is followed by instillation of 2 per cent formalin in glycerine, and it is sometimes worth while re-injecting 15–20 cc. of the aspirated fluid into the subcutaneous tissue, repeating this at intervals of two days. Surgical intervention, especially incision of the joint, should never be considered unless other measures have failed. Though it gives immediate relief, progressive ankylosis and joint destruction often follow. Mobilisation may be required if the joint is in a bad position and movement is greatly limited, while arthrectomy may be needed if there is marked bony ankylosis. In sub-acute and chronic cases rest is not so important. A local application such as iodex or Scott's dressing should be used. Bier's treatment should be tried, together with active and passive movements, massage, and contractions. It is in these cases that team-work with an orthopædic surgeon is essential if the best results are to be obtained. Diathermy is discussed in Chapter IV.

Treatment of Blood Infection. Arthigon and gono-yatren are two stock vaccines that I have found of service. Specific sera are rarely used, but anti-meningococcal serum, anti-bacsyn, edwenil and omnadin may all be tried. Auto-hæmotherapy has been recommended, and protein shock—aolan, T.A.B. vaccine, or peptone—may also be considered. Of chemico-therapeutic remedies, intravenous calcium gluconate, 10 cc. daily, may be given intravenously, contramine intramuscularly every fourth or fifth day, or iodo-septine intravenously every day. Quinine-hydrochloride, 7–10 grs. in 10 cc. of saline, can also be used.

The general health must be attended to by rest, hot hip-baths, aperients, and an abundance of bland fluids in the acute stages, with aspirin and drugs of this type, and later with general tonics and fresh air.

Fasciæ and Bones. Tenosynovitis, usually seen in association with arthritis, may, however, occur independently. It is mostly found in the

tendon sheaths of the extensors of the hands or feet, the tibialis posticus being commonly affected. The implication of this tendon, together with the plantar fascia and the inferior calcaneo-scaphoid ligament, may lead to flat-foot. *Bursitis*—less frequent—occurs under the tendo Achillis. *Myositis* and inflammation of the fascia may occur in any muscles which act on a joint affected by gonococcal arthritis, and marked wasting is often seen. During an attack of gonorrhœa, myositis may occur in *any* muscle, chiefly those of the back and loin. Fasciitis is mostly seen in the plantar and palmar fasciæ.

In the acute stages, treatment comprises rest, together with hot applications, massage, and active and passive movements, contractions with the Morton Smart coil being required later. It is only rarely that the bone and periosteum are attacked in gonorrhœal arthritis. *Periostitis* is a common condition occurring in the tibia, the lower end of the femur, and the humerus. *Periostosis*, due to an ossifying periostitis, is rare, affecting the os calcis and leading to the condition known as "gonorrhœal heel." This should not be confused with the painful heel due to plantar fasciitis. The treatment of these cases is essentially the treatment of the infected focus.

Less Common Metastatic Complications—Iritis and Skin Infections.

Iritis. Gonococcal iritis is more common than is generally supposed. It occurs especially in those cases which have arthritis, and usually follows at least one attack. It is nearly always seen in men, and, as a rule, both eyes are affected. Extension to the ciliary body may take place. There is a characteristic form which occurs in the acute attack when the anterior chamber shows a peculiar gelatinous exudate. *Iridocyclitis.* There is a form of recurrent iritis, iridocyclitis, in which there is a history of gonorrhœa and gonococcal rheumatism many years previously. The gonococcal infection is not revealed by culture or C.F.T., but there is often a streptococcal prostatitis secondary to some septic focus.

Skin conditions. The gonococcal conditions affecting the skin fall into four groups: (1) simple erythema associated with gonococcal septicæmia; (2) urticaria and erythema nodosum, occurring in arthritis, endocarditis and septicæmia; (3) hæmorrhagic and bullous eruptions, rarely in septicæmia; and (4) hyperkeratosis.

Hyperkeratosis (*keratodermia blennorrhagica*) (fig. 2900). This is not an isolated skin disease but a syndrome in which the following manifestations are concerned: (1) gonococcal urethritis; (2) polyarthritis; (3) inflammatory crusted lesions of the palms and soles; (4) intermittent pyrexia; and (5) cachexia.

The disease is probably much more common than is indicated by reports in the literature. It is associated with chronic gonorrhœa and is much more common in men than in women. The *primary lesion* is a vesicle which rapidly becomes a pustule, and the resulting crusts from the dried exudate give rise to the characteristic appearance. Vesicles are found on the softer skin of the chest, forearms and penis, and on the mucous membranes. The pustules become rapidly converted into hard, horny, conical lesions having a rupial crust. The characteristic lesions are on the plantar surface of the foot and the palmar surface of the hands, especially the former. There are two types of lesion—

Fig. 2900.—Keratodermia Blennorrhagica.

the diffuse and the conical. Balanitis circinata may also be found, and lesions may appear on the nails. The mucous membrane of the hard and soft palates may be involved. The eruption usually lasts from one to three months, when the plaques drop off, leaving a dirty reddish-brown macule. The disease is an allergic phenomenon.

Diagnosis has to be made from rupoid psoriasis, syphilis, and the bilateral hyperkeratosis seen in arsenical poisoning.

The treatment is that of the gonococcal focus and of the infected joint, together with some emollient applied locally.

Rare Metastatic Complications.

Perichondritis and chondritis are extremely rare. *Suppurative*

myositis may be seen in severe cases of suppurative gonococcal arthritis which has extended to the adjacent muscle. *Subcutaneous* and *intramuscular abscesses* have been recorded by various writers, most of them in connection with tendon-sheath infection. Cases of *parotitis* and *otitis* have also been described. *Metastatic conjunctivitis* is very rare. Both eyes are usually affected during the first attack, and the mildness of the symptoms distinguishes it from conjunctivitis due to direct local contamination. The prognosis is good. *Optic neuritis* and *dacryocystitis* may also be mentioned. The gonococcus has a great predilection for the endocardium, and though gonococcal *endocarditis* is not very common. it is less rare than is probably supposed. *Pericarditis* and *myocarditis* are extremely rare. *Aortitis*, *thrombosis*, and *phlebitis* are other conditions which have been described.

The *pleura* may be attacked independently or in conjunction with pneumonia, gonococcal septicæmia always being present. The symptoms are those of dry pleurisy or pleurisy with an effusion. It is unusual for the nervous system to be affected by the gonococcus. There may be a bilateral sciatica, but in these cases there is often a referred pain from a prostatitis and vesiculitis, though myelitis has been described, and the meninges of the brain and even the brain itself may be affected.

CHAPTER IV

Antiseptics, Vaccines, Diathermy and Surgical Measures

The gonococcus is peculiarly susceptible to germicides, and when outside the human body is destroyed with comparative ease by disinfectants in general and by variations in heat or moisture. Once, however, it has gained a hold in the genito-urinary tract it is most difficult to eradicate and exhibits a clinical chronicity and tenacity of life greatly at variance with the bacteriological properties it displays in culture media. These peculiarities are due to the fact that the localities attacked are so constructed anatomically that the germicides cannot react on the infecting organisms. When first deposited in a mucous membrane, gonococci can be readily killed and washed away, provided treatment is adopted before the organisms have penetrated below the surface epithelium. This is shown by the results obtained in the prophylactic treatment of gonococcal urethritis and in the Credé prophylactic treatment of ophthalmia neonatorum. When a few hours or days have elapsed the gonococcus will have penetrated below the mucous membrane, and antiseptics are then of much less value.

Experimental research has shown that although certain antiseptics penetrate the tissues, the presence of certain constituents in the mucosa tend to effect a chemical change in the antiseptic. This, coupled with the fact that the gonococcus tends to inhabit the depths of the mucous glands, accounts for its resistance to local treatment. It is well known that strong caustics by their irritant and destructive action rarely retard the course of gonorrhœa, but rather have the reverse effect.

Antiseptics.

The antiseptic of choice is one which is: (1) destructive of the gonococcus and other organisms that may be present in a mixed infection; (2) capable of penetrating the tissues without losing its germicidal properties; and (3) non-irritant. There is no antiseptic yet known that fulfils all these requirements. Preparations that may be employed are potassium permanganate 1 in 6000 to 1 in 4000, albargin (a silver nitrate and gelatine compound) 1 in 1000, oxycyanide of mercury 1 in 6000 to 1 in 4000, and acriflavine 1 in 6000 to 1 in 4000. Instillations and local applications include silver nitrate, 5–20 grs. to the ounce, and

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the various silver protein preparations, such as argyrol 10 per cent, protargol 5 per cent. neoreargon 5 per cent, neoprotosil 10 per cent. and lunosol 10 per cent. Another useful preparation is mesodine which belongs to the acridine dye series.

For all practical purposes potassium permanganate, oxycyanide of mercury and silver nitrate will possess sufficient antiseptic action to cure a case of gonorrhœa—potassium permanganate in the acute and most of the chronic stages, oxycyanide of mercury in chronic gonorrhœa (secondary infections), and silver nitrate when used as in instillation or for local application on a probe. In the acute stages albargin may be found less painful, and is cleaner for the patient than potassium permanganate. The solution can be made up fresh by dissolving the powder or tablet of albargin in tap or distilled water, the solution being clear and neutral or very faintly acid in reaction.

For instillation, silver nitrate is really a more efficient preparation than all the various silver protein compounds recommended, the merit of which is that they are less painful and produce less reaction. I have never seen any better results from acriflavine or mercurochrome in acute or chronic cases than can be obtained with potassium permanganate.

As the aim of all treatment is to help the tissue resistance of the part, so the use of any antiseptic must always be guided by its action on the membranes, and it is better to use saline or boric irrigations as a mere mechanical cleanser of a channel than to employ antiseptics which when used in a certain strength act as an irritant.

Specific and Non-specific Remedies.[1] In the treatment of gonococcal infections active immunisation with vaccine finds a useful place. Passive immunisation with sera has not been much used and is seldom considered. Of vaccines, a stock polyvalent preparation made from a large number of strains is often more effective than an autogenous one. But little is known of the antigenic components of the gonococcus, and until this has been investigated the polyvalent preparations are to be preferred.

Vaccines are usually employed in the early stages of acute urethritis, yet a few observers consider that small doses at the onset tend to decrease the incidence of deep-seated lesions. Doses of 5–20 million organisms at intervals of three days may be given in the early acute stage without doing any harm.

A certain proportion of cases of chronic urethritis and prostatitis are improved with gonococcal vaccine; others respond to inoculation with

[1] I am indebted to Dr. Lionel Whitby for the views expressed in this section.

vaccines made from secondary bacteria—especially streptococci—either alone or mixed with gonococci. On the average, an initial dose of 5 million organisms suffices with increases on the doubling principle, at 5–7 days' intervals, up to a maximum of 200–400 million. No great successes have been claimed with local lesions in the female. Vaccines find their greatest use in the treatment of metastatic manifestations—arthritis, tenosynovitis and iritis. Most cases respond well, especially if sub-acute or chronic. A prolonged course is necessary with a carefully graded dosage to suit each particular case. An initial dose of 5 million may be tolerated. Better results usually follow a maximum dose of about 400 million with thereafter a weekly dose of this amount over a prolonged period. Some few patients are highly sensitive and cannot tolerate maximum doses of more than 20–50 million; with these the dose should not be increased beyond the tolerated limit.

Many non-specific preparations have been advocated for the treatment of acute and chronic gonorrhœa. These preparations include sterilised milk, aolan, whole blood, S.U.P. 36, colloidal manganese, anti-bacsyn, edwenil, and omnadin. Most of these produce mild shock, with some leucocytosis and a quickening of metabolism that appears sometimes to be of benefit in the disease. More drastic intravenous remedies such as typhoid vaccine are of value in stubborn cases of rheumatism. It is difficult to say whether any one non-specific remedy can constantly exert a favourable action on the disease.

Diathermy. The application of diathermy to gonococcal infections is based on two facts: (1) that the gonococcus may be inhibited or destroyed by a rise in temperature; and (2) that in the part treated by diathermy there is produced an increased blood supply with stimulation of phagocytes or formation of anti-bodies. The heat to which the tissues are raised is 112° to 114° F., and at this temperature it is stated that gonococci are killed—*in vitro* they certainly are at a temperature of 102° to 105° F., but it is doubtful whether this is true *in vivo*. Diathermy has been used in cases of acute anterior urethritis, peri-urethral infiltration, prostatitis, prostatic abscess, vesiculitis, epididymitis and arthritis, and, in women, cervicitis and urethritis. In anterior urethritis it seems incapable of ending the infection more quickly than do other methods of treatment. In inflammation of the prostate and seminal vesicles the results are good, the best effects being obtained in combined treatment (focus and joint). In epididymitis the symptoms of inflammation and infection improve in a striking manner with the application of diathermy. The value of this treatment lies in its relief of pain, reduction of the swelling, and ability to bring fresh blood to the parts.

The temperature produced by it may devitalise the gonococcus, but it will not always eradicate it from the prostate and seminal vesicles.

In my opinion diathermy is simply a useful help in the treatment of gonorrhoea. It is not by itself a method of complete cure, and I do not yet see that it is a marked advance on the simpler methods of treatment —antiphlogistine and radiant heat to the joints, hot enemata for an acutely inflamed prostate, massage for the prostate and vesicles, and dilatation of the urethra.

Surgical Measures. These are dealt with in Volume II, Part XI.

CHAPTER V

Gonorrhœa in the Female

Gonococcal infection in the female affects both the genital and the urinary tracts, and it is necessary to have an accurate knowledge of the anatomy of the female pelvic organs before one can be fully conversant with the diagnosis and treatment of the infection in these parts. A short review of the essentials of anatomy and physiology as they concern gonorrhœa is given below.

Anatomy

Vulva (see fig. 2901).

The external female genitalia, known as the vulva, include the labia majora and minora, the clitoris, the urethral orifice and the vaginal introitus. Just within the urethral meatus are Skene's glands. These are simple—occasionally compound—tubular glands which usually have their openings on the posterior urethral wall; one lies on each side of the mid-line and extends parallel with the urethral canal for a distance of a quarter to half an inch. In the adult the whole vulvar surface is covered with squamous epithelium, and contains sebaceous and small mucous glands which open on the upper portion of the vestibule.

Bartholin's glands are two small tubulo-racemose glands the size of a broad bean, oblong in shape, which are situated in the posterior third of the labia majora. They are surrounded by a firm capsule and are buried in the vascular erectile spongy tissue of the labia majora. The duct of each gland opens on the inner side of each labium minus just in front of the hymen, from which it runs outwards and downwards for half an inch and splits into several main branches which are in turn distributed to the lobule of the glands. These glands and ducts do not develop fully till puberty, and they atrophy following the menopause.

Urethra.

The female urethra is a curved canal 1½ inches long with its concavity lying upwards and forwards, and for the most part embedded in the anterior vaginal wall through which it can be felt as a thickened cord. The meatus urinarius can admit a bougie of 24 Charrière. Behind the meatus the canal is of larger calibre and can easily admit a bougie of 24–30 Charrière. In the urethra are some follicles of much the same structure as the glands of Littré in the male, which at times become infected. Beneath the mucous membrane is a submucous layer of loose areolar tissue. This is surrounded by circular muscular fibres. The middle portion of the canal is embraced by a voluntary muscle, the compressor urethræ, which lies between the two layers of the triangular ligament. The hinder portion is surrounded by a well-developed involuntary sphincter muscle, the internal sphincter of the bladder. The mucous membrane is thrown into longitudinal folds, one of

which placed on the floor resembles the verumontanum. Under air distension these folds are obliterated, and the outer circular muscle is seen. Under high air distension these disappear, and the mucous membrane appears pale yellowish-pink, smooth and flat.

Vagina and Cervix.

The vagina is formed of one of the toughest fibrous membranes in the body. In its natural state it is lubricated by a secretion formed mainly of squamous cell, lymph. and lactic acid bacilli said to possess a natural anti-bacterial action. At its upper end it becomes continuous with the cervix, and the reflection of the mucous membrane of the vagina into the cervix forms the fornix. The epithelium is squamous and of considerable thickness, lying on a thick layer of erectile areolar tissue as it spreads over on to the protruding cervix. At the external os of the cervix the squamous epithelium gives place to the columnar epithelium of the cervical canal and projects into the glands that line it. The cavity of the cervix is fusiform, and broader at the middle than at either extremity. The wall of the canal presents anteriorly and posteriorly a longitudinal column from which proceed a number of small oblique columns giving the appearance of branches of a tree (arbor vitæ). In the upper two-thirds the cervical mucous membrane is provided with numerous deep glands which secrete a clear viscous mucus. In addition, extending through the whole length of the canal, are a varied number of little cysts which represent occluded follicles distended with retained secretion (ovula Nabothi). The mucous membrane covering the lower half of the cervical canal presents numerous papillæ. The epithelium of the upper two-thirds is columnar and ciliated, but below this it loses its cilia and gradually changes to squamous epithelium. The cervix uteri is undoubtedly the most important of all urogenital structures in gonorrhœa, for not only is it the point of entry of gonococci invading the Fallopian tubes, but it is also the commonest site of long-standing gonococcal infection. The openings of the cervical glands are protected by the arbor vitæ and by a plug of tenacious mucus. Above this the cervical canal narrows.

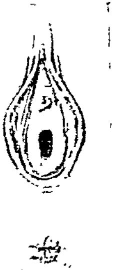

Fig. 2301.—The vulva.

Uterus and Tubes.

The mucous membrane of the uterus is unfavourable to the growth of the gonococcus. The mucous membrane lining of the Fallopian tubes consists of columnar ciliated epithelium thrown into a series of longitudinal folds. There is no submucous tissue, the epithelium being implanted directly on the muscular coat. Though the cilia act as a barrier against invasion of microscopic material from below, they are unable to deal with a spurt of menstrual blood.

Theoretically there is a far greater possibility of accidental gonococcal infection in the adult female than in the male, though it is probable that the disease does not occur more often in one than in the other. The infant female, on the other hand, is usually the victim of

extra-sexual infection. Her vulval mucous membrane, differing from that of the adult, is especially susceptible to the gonococcus, while the fact that she is compelled to submit to the administrations of others, in regard both to clothing and cleansing, increases the opportunities for the direct implantation of the organisms upon her mucous membrane through the carelessness of those who look after her. In the female the incubation is the same as in the male—usually three to five days. The fact that women are so accustomed to slight increase of vaginal and vulval secretions, and often to slight burning sensations at micturition, makes them very apt to overlook the beginning of a gonococcal infection.

GENERAL DIAGNOSIS

Inquiry should be made as to the approximate time when the patient began to notice any local irritation or unusual appearances, or symptoms such as increase in the amount, alteration in the colour or character of the vaginal secretion, or pain or burning during micturition. Questions should be asked as to the menstrual history—has the patient noticed any irregularities or pain; have there been miscarriages or attacks of peritonitis; is there pain on defæcation; have any children suffered from ophthalmia; is there a history of rheumatism or sterility? In many cases the information obtained is of little assistance, and a careful physical examination of the patient in the dorsal position on a table is always essential. The patient should have held urine for at least four hours previously.

Technique of Examination. The examiner sits in front with a head-lamp on his forehead and wears rubber gloves. At his hand is a surgical table containing the necessary instruments:

Mop holders. Playfair probes.
Urethral probes. Set of Charrière dilators 18–35.

A set of Hegar dilators.
A Cusco speculum (preferably Brewer's modification).
A Fergusson speculum. A Sims speculum, with anterior retractor.

Lucey's wire retractor speculum.
Egg-whisk cervical mucus forceps.
Short urethral tubes, 2 inches long, 18–22 Charrière.
Skenoscope (see fig. 2902).

These instruments should have been boiled and laid out in an antiseptic lotion by the nurse. It should be remembered that electric light makes white appear yellow, and may thus cause the normal secretion of the urethra to be mistaken for pus.

The abdomen is first palpated for areas of deep tenderness, and for

swellings of the pelvic and other abdominal organs. Examination is made for enlarged inguinal glands or for rashes on the skin. The amount, character and reaction of the vaginal discharge should be noted. Microscopically, the normal discharge shows squamous cells, and Döderlein's long, thick, Gram-positive, non-motile bacillus. Pathological discharge, which is barely acid or alkaline in reaction, is frothy and contains mucus with enormous numbers of bacilli and cocci with or without pus cells. In examination of adult females for gonorrhœa it is not necessary to take smears for films and cultures.

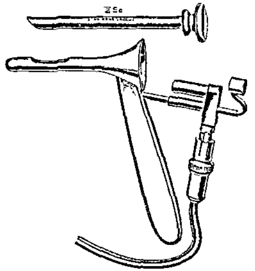

Fig. 2902.—Skenoscope, with Young's attachment.

Excess of normal secretion is found in pregnancy, sexual excitement or sexual excess, anæmia, and emotional conditions.

General naked-eye appearances. The labia majora may appear red, tender, swollen, and glued together by profuse purulent discharge, or they may be covered by small warts, or large, coalescent, cauliflower-like growths with broad sessile bases, even extending up into the vagina—condylomata acuminata. In this condition, which is due to uncleanliness, the discharge is offensive, and is often accompanied by a sharply defined dermatitis of the genito-crural and peri-anal region. The hair follicles may be inflamed, and superficial non-indurated sores may be concealed by them. Scrapings from these should be subjected to careful dark-background examination, and the inguinal glands should be palpated. A non-inflammatory œdema of the labium may cause a suspicion of primary syphilitic infection. Condylomata of secondary syphilis, leukoplakic patches, or ulcers (tuberculous, malignant or syphilitic, or from Vincent's spirillum or Döderlein's bacillus) may also be seen. Soft sores, with irregular margins, accompanied by enlarged,

tender glands, invite a diagnosis of infection with Ducrey's bacillus. Herpetic vesicles, phagœdema, and lymphogranuloma inguinale may also be observed. The openings of Bartholin's glands can usually be seen with the naked eye, but a magnifying glass may be necessary. When there is inflammation of the ducts a characteristic circle appears round the opening (macule of Sänger). In other cases the opening of the duct will appear as a mere red spot, as part of a general punctate erythema in vulvitis. Enlarged Bartholin's glands can be palpated with the thumb and index finger within the lower portion of the labia majora. It is almost impossible to feel a healthy Bartholin gland on palpation.

Examination of the Urethra. Inspection may reveal a reddened pus-covered mucous membrane pouting through the lips of the urinary meatus, and the surrounding parts may be inflamed and covered with pus. The urethra may be milked from behind forwards by means of a gloved finger in the vagina for discharge, and if this is unproductive a specimen for smears and cultures may be obtained with a platinum loop.

Skene's tubules should be examined for swelling or discharge. The patient then passes urine into two glasses. If it is clear, with yellow muco-purulent threads, there is a chronic urethritis. If the first glass shows a purulent haze and the second glass is clear, there is probably no cystitis or pyelitis and the urethritis is not very severe. If both glasses show purulent haze, then either the urethritis is very severe or there is cystitis or pyelitis. If there is no pus in the urethral films, or pus cells with no gonococci, it is almost certain that pyelitis and not urethritis is present.

Examination on these lines should make an accurate diagnosis of acute gonorrhœa possible at once, but in other cases three consecutive examinations should be followed by others on different days before it is concluded that the gonococcus is absent.

Vagina and Cervix. After thorough cleansing of the vulva, a Cusco speculum is introduced. The vaginal walls may be red, swollen, tender, roughened, and bathed in purulent secretion, the cervix appearing smooth, rather paler, and having no erosion or pus issuing from it. Clinically, this appearance is typical of a non-infective vaginitis. A smooth and pale vagina, with a red, swollen and œdematous cervix exuding pus or showing an erosion, is typical of a gonococcal cervicitis. A pale vagina with a rather paler smooth cervix is the normal appearance.

Finally, the surface of the cervix and the interior of the canal are

thoroughly dried. (A vaginal douche before examination is no deterrent to the finding of gonococci in the cervical canal.)

Uterus and Tubes. When the speculum has been withdrawn, a complete bimanual examination is made for swelling or tenderness in the fornices, ovaries or tubes. The uterus is examined for mobility and position, and for the presence of any parametrial or perimetrial swelling or tumours.

The key to success in the treatment of gonorrhœa is the painstaking and adequate examination of each successive portion of the urogenital tract A doctor working in a V.D. clinic will gradually find that his eye becomes trained to recognise all sorts of characteristic clinical appearances, and he will be able to co-ordinate this clinical knowledge with what the bacteriologist actually finds. He will build up a good clinical knowledge of the disease controlled by laboratory methods—it is this which makes for success in the treatment of venereal disease.

TREATMENT

General Instructions to the Patient. As in male venereal disease, instructions to the patient are of the greatest importance. A scheme for this is given below:

(1) You are infectious to a man until the doctor passes you as cured. The absence of vaginal discharge does not necessarily mean that you are cured.

(2) During the painful stages of the disease rest in bed if possible. If a menstrual period comes on, go to bed until it is over.

(3) You must refrain from all forms of alcohol. Drink plenty of fluids—water, lime-juice, orange-juice, barley-water, or natural mineral waters.

(4) There is no need to starve yourself on a milky or slop diet. Eat plenty of simple solid food, but avoid such articles of diet as curry, mustard, pickles, spices, ginger, etc.

(5) Sit in a hot bath once daily for a quarter of an hour, so as to foment and wash the parts. A two-pint saline douche at low pressure should be given daily.

(6) You may convey the discharge to your own or to your child's eyes. Therefore always wash your hands carefully after douching or handling the parts, adding a teaspoonful of lysol or listerine to a hand-basin full of water. Always wash and dry the face before getting into the bath. Use a separate towel for the face, and be specially careful that your own towels and sponges are not used by the children or by any other person. Do not soil the seat of the water-closet, and do not use a chamber which your children are in the habit of using.

(7) You must refrain entirely from any kind of sexual excitement until you are passed as cured.

(8) Do not ride a horse or bicycle until you are cured.

(9) Do not worry. The disease is always curable, but the cure may take several months.

Vulvitis. In addition to invasion by the gonococcus, mycotic infection, uncleanliness, and irritant douches and applications may be responsible for this condition. It is only with difficulty that a lesion

of stratified epithelium can be produced by the gonococcus, and were it not for modification due to local conditions, such as moisture, friction and discharge, gonococcal vulvitis—already uncommon—would be less frequent in the adult than it is. When it does occur it is nearly always secondary to gonorrhœa in other portions of the genital tract, and results from the irritating discharge thus produced.

Symptoms, Signs and Diagnosis. The patient complains of a feeling of heat and swelling in the vulva, together with irritation, considerable pain and discomfort, a profuse purulent discharge, and usually some burning on micturition. Inspection and palpation reveal swollen, red, tender labia, glued together by the discharge. It is useless to take smears and cultures of vulval and vaginal discharge; the gonococcus must be searched for in the urethral and cervical smears. In cases due solely to uncleanliness, the organism is absent, the discharge is of a most unpleasant and characteristic odour, and warts (condylomata acuminata) and local dermatitis are seen. In vulvitis due to the irritation from douching and local applications, the history, and the excessive swelling of the labia, which are often covered by excoriated areas, will suggest the diagnosis.

Chronic Vulvitis. This may follow an acute vulvitis, or come on insidiously without any acute symptoms. The causes are gonococcal infection and the subsidiary factors mentioned above. To these may be added eczema, herpes, pediculi, scabies, glycosuria, and the congestive pruritus of pregnancy. The patient complains of local itching or soreness, and of slight increase in vaginal secretion. The vulva is not appreciably swollen, but the surface is rough and covered with a thin mucoid discharge. Abrasions, erosions and warts are often seen on the inner surface of the labia, and there may be dermatitis. In the case of gonococcal infection, the organism will not readily be found in the vulval discharge.

VAGINITIS

Pathological vaginal discharge may arise from the vagina itself, but often it comes from the cervix, the uterus, the Fallopian tubes, the pelvic peritoneum, the pelvic cellular tissues (after a burst abscess), the urethra, and even the rectum. The common causes are gonococcal infection, uncleanliness, sepsis, pregnancy, miscarriage, prolapse, dilatation of the cervix, foreign bodies (such as unclean pessaries), the use of irritant douches, and (commonly) infection with the trichomonas vaginalis. The patient complains of a profuse vaginal discharge, of intense irritation, of heat and spasm in the vagina, and often of painful micturition and defæcation. On inspection the vaginal lining is tender

to the touch of the speculum, and appears to be steaming with heat; its walls are red, swollen, and roughened, presenting a strawberry appearance due to inflamed papillæ.

Gonococcal vaginitis is secondary to gonococcal cervicitis and urethritis, so that the diagnosis is made by finding the organism in either of these sites. In puerperal cases the history and the torn cervix will lead to a correct diagnosis. In cases due to irritant douches the history, the excoriated vulva, and the bullous appearance of the vagina and vulva will suggest the cause. Trichomonas infection should be suspected if the discharge is profuse, yellow, offensive and frothy, and if it causes a very acute inflammation of the vagina with numerous small red areas on the wall and cervix. It should be realised that this infection may be considered as a venereal disease. This infection may arise:

(1) From the anus, the infection being mechanical from the result of cleansing the anal region from behind forwards; or

(2) From sexual intercourse, examination of male contacts showing evidence of chronic prostatitis, and non-hæmolytic streptococcus with trichomonas vaginalis in the prostatic secretion (*Lancet*, Dec. 21, 1935).

Examination of the vaginal discharge is important in trichomonas infection. The flagellate protozoon, which varies in size from a little larger than a polymorphonuclear leucocyte to a little smaller than a vaginal epithelial cell, can easily be recognised under the microscope by its motility.

Treatment of Acute Vaginitis. In adults the primary focus in the cervix or urethra is attacked. If possible the patient should be confined to bed and ordered to take a hot sitz-bath night and morning. A saline douche at low pressure is given to the vagina, and then, after it has been thoroughly dried out, linamentum calaminæ is poured into it and applied to the vulva. When the acute symptoms have subsided, the cervical canal and vagina can be swabbed with acriflavine 2 per cent in glycerine daily, a saline douche being later given twice weekly. In cases due to the trichomonas vaginalis, the treatment consists in a daily douche of lactic acid, ½ drachm to the pint, followed by the insertion into the fornices of devegan tablets.

Chronic Vaginitis. This may follow an acute attack, but it is often chronic from the onset. The symptoms are irritation, excessive vaginal discharge, and painful micturition. Examination reveals a thin, profuse, purulent vaginal discharge, and an increased redness and roughness of the vaginal mucous membrane. In pregnant women there is a form known as granular vaginitis (non-gonococcal). In this condition

the discharge is green and tenacious, while the vagina shows red, raised, hard nodules scattered uniformly over its surface. Treatment applied to the cervix and urethra gradually leads to the disappearance of a chronic gonococcal vaginitis. In simple chronic vaginitis, douching, and general treatment by fresh air and exercise, with iron and aloes administered internally, is important.

Bartholinitis. It was held for many years that all inflammation of Bartholin's glands was due to gonococcal infection. This is not correct. The gonococcal infection of the vulva and vagina may spread to the duct and be limited to it. In this case it can be seen exuding a drop of pus and surrounded by a red circle of inflammation—the macule of Sänger. Any swelling of the gland is simply caused by a retained mucoid secretion. Inflammation may, however, spread to the deeper tissues of the glands and give rise to a diffused inflammatory swelling of the whole or part of the gland. This may subside with complete resolution, or may leave behind a chronic inflammatory thickening of the gland. Sometimes the inflammation is so acute that an abscess is formed in part of the gland. In relapsing cases it is better to excise the whole gland rather than to open abscesses as they arise. Bartholinitis is usually associated with vulvitis and vaginitis, but it may occur by itself.

Diagnosis. The orifice of the duct is examined; it may appear as a mere red spot on the surface of the reddened mucous membrane, which disappears in a few days when the vaginitis and vulvitis have cleared up. If, however, the macule of Sänger is present surrounding the opening of the duct, then there is a definite "ductitis" as a separate entity (see fig. 2903). If pus can be expressed, a smear should be examined for gonococci and other bacteria. If no enlargement of the gland can be felt, a diagnosis of ductitis should be made. If, on the other hand, the gland is felt to be enlarged, a fine cannula should be inserted and the duct syringed out with 2 per cent flavine. The enlarged gland can then be squeezed and the character of the resultant secretion noted. In some cases this is found to be mucoid and sterile—that is, a mucoid retention cyst secondary to acute ductitis is present. In some cases the gland goes on to abscess formation and the pus points above and outside the duct opening, or may burrow and point in the perineum or burst in the rectum. It is not always easy to detect the gonococcus in pus from a Bartholin abscess. If, however, the organism is present in the urethra or cervix, there can be little doubt that the abscess is gonococcal. The differential diagnosis of an abscess of this gland is from an infected hæmatoma or cellulitis of the labium majus, or even from an ischio-rectal abscess.

Treatment. In the case of acute ductitis, a fine probe is introduced into the duct so as to dilate the orifice. Pus can then be squeezed through the enlarged opening. The nozzle of a fine syringe is then inserted, and a little 2 per cent flavine is instilled into the duct and gland (fig. 2904). This line of treatment can be combined with gentle massage three times a week. A cure should be speedily effected in this way. When an acute adenitis (suppurative or non-suppurative) has subsided, massage of the gland can be carried out after the duct has been dilated with a probe, this being followed by flavine instillation. In cases of acute inflammation of the gland, with fever and swelling which is becoming daily more acute, a large vertical incision should be made into the most prominent part of the swelling, the contents

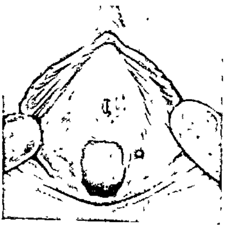

Fig. 2903 —Bartholinitis (macula of Sänger).

evacuated, and a drainage-tube inserted. When the incision has partly healed and some gland tissue is made out on palpation, then attempts to cure the remainder of the infected gland should be made by washing out through the duct. Only if this fails, or if there are recurrent abscesses, should the gland be excised. The clean removal of a chronic infected Bartholin gland without leaving any infected tissue behind may involve severe hæmorrhage and is not an operation to be undertaken lightly. (See also Vol. II, page 2385.)

ACUTE URETHRITIS

Urethritis in the female is usually of gonococcal origin, but there are a number of cases where it is caused by other bacteria. The causes of the non-gonococcal cases are excessive sexual excitement, masturbation, a septic catheter, trauma from coitus or at childbirth, or a descending or hæmatogenous infection set up by a primary blood infection of the kidney. As in the male, acute gonococcal urethritis, after an incubation

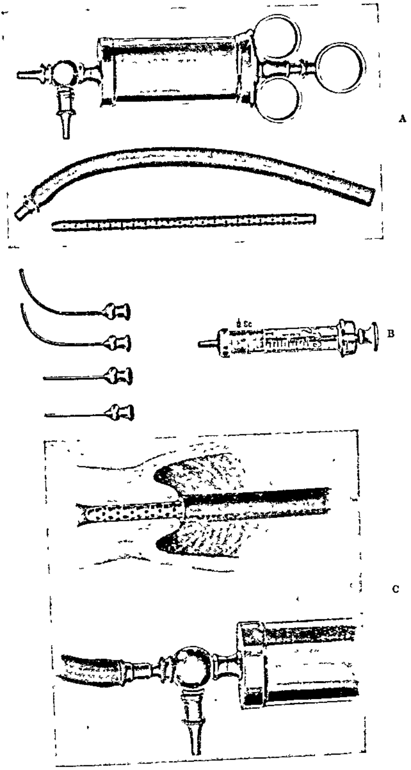

Fig 2904

A. Pedroso suction apparatus for cervix.
B. Syringe and cannulæ for use in cases of Bartholinitis.
C Pedroso instrument in position in cervix.
(*From Kidd and Simpson's "Common Infections of the Female Urethra and Cervix" Oxford Univ. Press*)

of 2–10 days, generally 3–5, runs a definite self-limited course and tends at the end of 3–4 weeks to die down and either clear up altogether or become chronic. In the female it runs a far less severe course than in the male.

The gonococcus induces an inflammation at the entrance to the canal which quickly spreads backwards to the deep urethra and to the trigone of the bladder. It rarely travels beyond this point. Gonococcal cystitis is very uncommon, and ascending gonococcal pyelitis is practically unknown.

Symptoms and Diagnosis. The chief symptom is a burning pain as soon as micturition is started, lasting throughout the act and ceasing as soon as it is completed. This pain differs from the terminal pain of

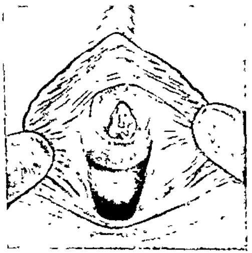

Fig. 2905.—Acute Urethritis. Purulent Discharge.

micturition due to B. coli infection. Inspection of the vestibule reveals a reddened, prolapsed, pus-covered mucous membrane pouting through the lips of the urinary meatus (fig. 2905). The parts around are inflamed and covered with pus, a drop of which may be seen exuding from the meatus. By milking the urethra forward, enough discharge may be obtained for a smear to be made. In the absence of discharge the platinum loop may be passed into the urethra. Skene's tubules should also be examined for pus. The patient should then pass urine into two glasses.

Treatment. Rest in bed is the ideal general treatment. In very acute cases with profuse urethral discharge and intense burning irritation, the urethra is so exquisitely tender that a nozzle cannot be introduced into it. It may then be advisable to postpone all local treatment until the sharpness of the inflammation has subsided. In

such cases a mixture of potassium citrate 30 grs., potassium bicarbonate 15 grs., tinct. hyoscyami 20 minims, infus. buchu to 1 oz. (or elixir saw palmetto et santal) is given and the patient is kept in bed for a few days, with daily hot sitz-baths, and taking a light diet and plenty of fluids. In the average acute case of moderate severity, urethral and vesical irrigation should be carried out, using 1 in 6000 acriflavine or 1 in 6000 potassium permanganate. There is no danger of "driving the disease back," as gonococcal cystitis and pyelitis are almost unknown. The irrigator is raised to a height of two to three feet above the level of the urethra and is filled with two pints of fluid. The metal urethral nozzle is gently introduced for an inch into the urethra, and the fluid allowed to run until about a pint and a half of fluid has been used. The nozzle is then gently worked forward until it reaches the bladder, when a half-pint of fluid is allowed to run in and, after being held for a few minutes, is voided by the patient.

In the majority of cases a complete cure can be brought about by this method in four weeks. If there is no discharge seen on a four-hours' retention of urine, and the urine is clear, the treatment should be discontinued for some days, and a test ("two glass," film and culture) made. If these tests still show no gonococci after provocative alcohol, the patient can be passed as cured of the urethritis and no further treatment of the urethra is required, even though the cervix may be still affected. If the tests are still positive after 4-6 weeks' treatment, the disease has entered on the chronic stage, and requires special treatment.

CHRONIC URETHRITIS

In the untreated infected female the gonococcus tends to live longer in the urethra than in any other part of the urogenital tract. The gonococcus carrier is typically the female with a symptomless chronic urethritis. There are usually no symptoms of a chronic urethritis which are noticed by the patient. Occasionally she is aware of a sensation of itching, and sometimes there is slightly increased frequency of micturition in the daytime. Less commonly a chronic trigonitis of gonococcal origin will cause some frequency and even pus at the end of micturition. In cases of suspected chronic gonococcal urethritis, at least three careful examinations of the urethra must be made, and the patient should have held urine for six hours at the minimum, and preferably all night. Films and cultures should be made of whatever secretion can be obtained, and Skene's tubules and the para-urethral follicles should be carefully examined.

In chronic urethritis the urine is usually clear of any purulent haze,

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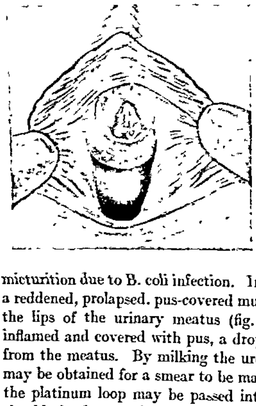

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In chronic urethritis the urine is usually clear of any purulent haze,

and merely contains a few hazy threads which should be examined for gonococci.

Treatment. The routine treatment consists of dilatation of the urethra and urethro-vesical irrigation, with, later, painting of the urethra with silver nitrate solution, 5–20 grs. to the oz. The patient having passed water a straight French steel bougie lubricated with lubafax or K Y jelly is passed into the bladder. The size of this is worked up at intervals of four or five days to 30–32 Charrière—*never* beyond 35—each dilatation being immediately followed by a urethro-vesical irrigation with 1 in 6000 potassium permanganate or 1 in 5000 acriflavine, which is given daily. Such dilatations hasten cure in a striking way, and also facilitate urethra painting. The latter is carried out by passing a short urethroscopic tube (22–26 Charrière) up to the neck of the bladder The obturator is then withdrawn and any excess of urine is allowed to fall out of the tube. A metal or wooden stick carrying cotton wool dipped in silver nitrate solution is then passed through the tube to the neck of the bladder. The tube is drawn away, leaving the mop in its place. The urethra is painted as the tube is withdrawn. This is repeated every fourth or fifth day, and at each sitting the strength of the solution is increased from 5 grs. to the ounce up to 40 grs. if need be. This combined treatment by dilatations, irrigations and paintings usually brings about a cure in four to six weeks. If it fails, then urethroscopic examination should be carried out to detect complications.

COMPLICATIONS OF URETHRITIS

These may be classified as follows: (1) Infection of Skene's tubules, lacunæ, and follicles; (2) infection of the para-urethral follicles; (3) sub-urethral abscess; (4) stricture; (5) polypus; and (6) infection of congenital pouches.

"*Skenitis*" is not a common complication. When one or both Skene's tubules are infected, the lips of the meatus are usually everted and pouting, so that the floor of the urethra is slightly prolapsed and the orifices of the tubules are visible, often exuding pus. When the orifices are not clearly seen, they can be exposed by means of Lucey's speculum. If the tubules are infected, a fine probe on which silver nitrate has been fused is passed into the duct to its extreme limit, and the gland is burned out. If this treatment fails, the gland should be cauterised with a fine galvano-electric cautery point. In some cases a small sub-urethral abscess will arise as the result of this infection, and will have to be opened either sub-urethrally across the vaginal wall, or by inserting a director into the duct and slitting it open until

pus is freely struck on the floor of the urethra. The cavity should be burned out with the cautery.

Para-urethral Follicles. These correspond to the para-urethral canals met with around the male urethra. If they are infected, pus can be seen issuing from their mouths, which are surrounded by a red areola. A silver nitrate-covered probe or fine cautery point introduced into the depths will quickly bring about a cure.

Sub-urethral Abscesses. These may arise from infection of Skene's tubules or of ducts or glands lying nearer to the bladder on the floor of the urethra. The inflamed duct is blocked by fibrous tissue laid down in its walls so that the deeper portion of the gland or pit becomes distended with pus, and its wall surrounded by fibrous tissue. If left to themselves these abscesses usually burst, and may give rise to far-spreading fistulous tracks which open a long way from their point of origin. At other times the pus becomes pocketed and lies dormant for months or even years, to be lit up at any time and so cause an apparently fresh attack of gonorrhœa. Whenever sub-urethral swellings are detected—acute or chronic—they should be freely opened where they point, and the wall of the cavity should be burnt with the actual cautery or the silver nitrate probe.

Stricture. Mild degrees of stricture of the urethra are not so very uncommon. They may cause irritation of the bladder, with some difficulty in micturition and sometimes severe pain. On examination it is found that the urethra does not admit a 22 Charrière. Cystoscopy shows a chronic trigonitis. The treatment consists in gradual dilatation of the urethra up to 32 Charrière and not beyond 35 Charrière, and this should effect a cure. This may be followed by treatment with the irrigating Kollmann dilator. A general anæsthetic may be necessary for the first few dilatations.

Polypi. Long-stalked polypi occur at times as a result of chronic urethritis, and these can be effectively treated by fulguration.

Infection of a *congenital pouch* is very rare.

URETHROSCOPY IN THE FEMALE

Routine urethroscopy is perhaps not so necessary in the case of the female urethra as it is for the male, and it is usually reserved for difficult cases which fail to clear up with the treatment just described. The urethra can be examined by either: (1) an air-distension urethroscope; (2) a urethroscope of the Hugh Young type (no air distension); or (3) the skenoscope. In acute urethritis it is not advisable to carry out a urethroscopic examination.

Air-Distension Type. In very sensitive women a general anæsthetic may be required, but usually a local anæsthetic is sufficient. The patient is placed in the Kelly position, the bladder is emptied with a catheter, and 2 drachms of a 4 per

cent solution of novocaine are injected into it and left for ten minutes. Cotton wool on a holder soaked in the same solution is passed into the urethra and left there for the same length of time. A short urethroscopic tube, 2½ inches long and of 24–26 Charrière bore, is passed into the bladder. The tube is made slightly tapered (and not conical) so as to prevent the escape of air. The obturator is withdrawn, any excess of urine being allowed to escape, and the lighting attachment is then fixed in place and air immediately allowed to flow into the tube. The bladder being distended with air, a perfect view is obtained of the trigone. The tube is now gradually withdrawn into the urethra. As this is done, the internal sphincter is seen to close behind the tube, and the walls of the urethra itself blown out with air are now revealed. The air distension obliterates the natural longitudinal folds of the urethra, and only the circular muscular fibres are seen. In chronic urethritis, areas are seen where the urethra is reddened and swollen and fails to dilate fully under air distension. This is the intermediate type of stricture. Fibrous crescents and circular fibrous strictures are seldom seen. In other cases a red areola surrounds the mouth of a duct or gland from which pus exudes. Sometimes the gland itself is swollen with pus, so that its body bulges into the distended lumen.

Hugh Young's Urethroscope. In order to use a silver nitrate-covered probe or the actual cautery, it is necessary to have a urethroscope of the Hugh Young type, which has no air distension. A short wide tube is used, the light and a magnifying glass being so disposed that it is possible to manipulate an instrument into the mouth of an infected follicle previously noticed with the air-distension urethroscope.

I do not wish to lay too much stress on urethroscopy in the treatment of gonococcal urethritis in the female. A cure can be effected in fully 97 per cent of cases by irrigations, dilatations and paintings.

CERVICITIS

According to Menge, cervicitis occurs in 80 per cent of acute and 90 per cent of chronic cases of gonorrhœa. The gonococcus is implanted directly into the cervix at the infecting act, and does not ascend from the urethra, vulva or vagina. At first sight it would appear that, once implanted into the cervix, nothing can stop the gonococcus rapidly spreading to the body of the uterus and the Fallopian tubes. This is not the case. Several factors play a part in preventing such a spread—the plug of mucus at the internal os, the constant renewal of the uterine mucous membrane every month, and the antibacterial properties inherent in the tissues of the uterus. This antibacterial barrier breaks down when parturition or miscarriage occurs, if there is an early menstrual period supervening on the initial attack of gonococcal infection, and if the woman remains out and about in such circumstances. It is thus essential to treat and cure gonorrhœa in pregnancy, and to start treatment of the infected cervix from the

very commencement of the disease, so that the infection is controlled before the menstrual period comes on.

Gonococcal infection tends to localise itself in the true mucosa of the cervical canal. In the great majority of cases the infection originates as an endocervicitis. As a result of hyperæmia of the canal—giving the appearance of a wide ring of red, angry-looking œdematous swelling —a portion of the canal will project, and in a chronic or severe case the inflammation may involve the adjacent squamous epithelium of the vaginal portion, so that on examination the external os appears as a bright red spot surrounded by an infiltrated granular area of more or less limited extent—the so-called *cervical erosion.* This is due to the stratified squamous epithelium of the vaginal portion of the cervix being pushed away by a copious infiltration of small round cells—sometimes by rupture of an underlying retention cyst—and the denuded surface becoming rapidly covered by the mucosa from the canal. A cervical erosion is not an erosion in the true sense—that is, an ulceration or breach of epithelium. It is velvety to the touch and does not bleed unless roughly handled. If the cervicitis is of long standing some of the ducts of the cervical glands may become blocked, and it is in this way that the retention cysts (ovula Nabothi) already referred to arise. (See also Vol. II, page 2258.)

A few days after the gonococcus is implanted within the cervical canal, the cervix becomes hot, red and swollen, and pours out a copious purulent viscid discharge. The severity of the inflammation varies with the virulence of the organism, the general state of health of the patient, and the life she leads. In many cases the inflammation is subacute or chronic from the outset; at other times it is at first acute, but in the course of 3–4 weeks either resolves naturally and leads to a natural cure, or, which is more likely, enters upon a chronic course. Gonococcal cervicitis divides itself into the acute and chronic varieties, each of which presents two definite types, according to whether the patient is nulliparous or multiparous.

Acute Cervicitis. The only constant symptom in acute cervicitis is discharge from the vagina. Pain is seldom a marked feature, but if present it consists of a dull ache felt in the middle line of the back at the upper portion of the sacrum. There is no fever unless there is an accompanying enlargement and tenderness of the body of the uterus. This complication, which is usually brought on by exercise taken during menstruation, produces slight fever and great aggravation. Menstruation may subsequently become irregular and profuse. Examination by means of a speculum during the acute stages shows, in a *nulliparous*

cervix (Type 1). a red angry areola, with marked œdema surrounding a sharply-cut circular external os from the centre of which yellow pus pours out. In the *multiparous cervix* (Type 2), the inflammatory area is more subdued and less œdematous, and surrounds an irregularly torn cervix, showing an old chronic erosion oozing forth yellow tenacious pus.

Chronic Cervicitis. This presents few if any symptoms beyond a complaint of excessive vaginal discharge which increases in quantity at the menstrual period or during pregnancy. The discharge is thinner than that of acute cervicitis, and it is often faintly acid or even distinctly alkaline. Exposure of the cervix through a speculum reveals a characteristic picture. In the *nulliparous* case (Type 1) the cervix itself does not appear swollen or inflamed, but ropes of tenacious, yellow, purulent mucus exude in profusion from the cervical canal and have to be swabbed away before a clear view can be obtained. There is then often revealed an irregular reddish patch, the cervical erosion already described. As the disease clears up under treatment or by the natural process of repair, the erosion usually disappears, when the mouth of the cervix may return to its normal appearance or may, as a result of scar tissue formation, become irregular and narrower. It is at this stage that mucous retention cysts or even mucous polypi bulging from just within the cervix canal may be seen.

In the *multiparous* case (Type 2), an apparently healthy-looking cervix is seen with no erosion at all, or else the cervix shows a pale erosion and a tear, with clear jelly-like mucus, free from pus, issuing from the canal This mucus yields a pure culture of gonococcus. A history of abdominal pain and menorrhagia may be obtained in these cases and there may be tenderness and resistance in the fornices.

Differential Diagnosis. The diagnosis of acute cervicitis is readily made by the clinical appearance of the cervix and by an examination of films and cultures obtained from the cervical canal. Chronic gonococcal cervicitis can only be recognised by means of films and cultures of the cervical discharge, the existence of an erosion, which is twice as common in non-gonococcal as in gonococcal cases, being by no means specific. An external os which shows no laceration and is surrounded by a circular erosion is, however, strongly suggestive of gonococcal infection. Cervical erosion must also be distinguished from early carcinoma, syphilis and tuberculosis.

Carcinoma. The more advanced age of the patient, the history of bleeding rather than of yellow discharge, and the absence of painful micturition are helpful points in the diagnosis. Carcinomatous ulcer is more friable and bleeds more easily; its edges are irregular and everted, and its base invades the deeper tissues and feels characteristically hard.

Primary Syphilis. A primary chancre of the cervix may present the appearance of a small ovoid area of superficial ulceration showing relatively few signs of

inflammation (chancrous erosion) and exuding a thin serous fluid, or this area may be surrounded by a very slightly raised and hard ring (chancrous ulceration), or it may simply constitute a hard, brownish-red papule covered with a thin sanious discharge, or present a localised area of non-inflammatory œdema with no obvious breach of surface. The characteristic enlargement of the inguinal glands will assist the diagnosis.

Cervical Tuberculosis. This is a rare condition which is more likely to be seen in young girls than in adults. There is a velvety ulcer with ragged undermined edges which readily bleed. Evidence of tuberculosis in the Fallopian tube and peritoneum enables a correct diagnosis to be made.

Treatment of Acute Cervicitis. The patient should, if possible, be kept in bed—especially during the menstrual period, when treatment is suspended—and should be placed under the general regimen described in the early part of this chapter. It is advisable to apply antiseptics to the inflamed cervix during the acute stage, and this should be carried out daily, if possible, for the first week, and afterwards every second or third day. The patient is placed in the examining chair, and the cervix is exposed to sight. The vagina is thoroughly cleansed and dried. A Playfair probe covered with sterile cotton wool is then passed into the cervical canal, and the tenacious, ropy pus is removed by twisting the probe. If the pus is very tenacious it is advisable gently to introduce a pair of egg-whisk cervical mucus forceps, and twist out the rope of muco-pus, or, alternatively, liquor potassæ can be applied on cotton wool and left *in situ* for a few minutes to dissolve it out.

It is most essential to get rid of all the pus before applying antiseptics to the bare membrane.

In the nulliparous patient (Type 1) a mop of wool on a Playfair probe is then dipped in acriflavine, 2 per cent in glycerine, or mesodine, and the cervix is thoroughly swabbed out with this up to the internal os. The vagina and vulva are then painted over with the same application, and the following morning the patient has a two-pint saline douche. Both cervicitis and vaginitis clear up very rapidly under such treatment, and in cases where there is no pelvic involvement a cure can sometimes be effected in ten to fourteen days. Acriflavine and mesodine seem to possess a very low toxicity for human tissues combined with a high bactericidal action. They appear to be diffusible and to spread deeply into the cervical glands and into the areolar tissue. In cases of irritation, calamine linament can be applied to the vulva and vagina, and applications can be suspended for a few days or replaced by 10 per cent eucalyptus oil in sterile olive oil. I do not employ silver nitrate or silver protein preparations in acute cervicitis.

In the multiparous patient (Type 2), with scar tissue and poor

drainage, there is usually a pocket of pus just in front of the internal os, that is, in the deeper part of the cervical canal. The patient is placed in Kelly's position, the vulva and vagina are thoroughly cleansed with acriflavine, 2 per cent in glycerine, and the cervix is dilated very carefully, if possible up to No. 6 Hegar, the instrument being passed just through the internal os. A gush of pus is often seen as the dilator is withdrawn. After that, a smaller Hegar (No. 4) is passed up the canal and moved gently up and down whilst the vagina is filled with the acriflavine solution. This is repeated every fourth or fifth day. By such a method of treatment a rapid cure is effected in cases which have proved resistant to the simple swabbing out of the canal, but in which there has been no history or clinical signs indicative of the infection having spread to the tubes.

By another method the Hegar dilator is passed just through the internal os and withdrawn An intra-uterine syringe of the pattern designed by Stanley Dodd is then passed, and from 2–5 cc. of acriflavine, 2 per cent in glycerine, is injected. This is often followed by rather severe uterine contractions, and any intra-uterine syringing or the passage of a Hegar dilator through the internal os must be undertaken with the greatest care, never being carried out if there is any resistance There is always the danger of shock, and an anæsthetic is usually advisable.

Treatment of Chronic Cervicitis. If cases fail to clear up completely on the acriflavine treatment, or if the patient applies for treatment during the chronic stage, antiseptics of a caustic nature, which are able to soak not only into the glands but also, to a limited extent, into the surface of the mucous membrane, are applied to the cervical canal.

In nulliparæ (Type 1) the cervix is exposed as before, but the tenacious, ropy mucus is harder to remove than in the acute cases, and it is generally necessary to use the egg-whisk cervical mucus forceps or applications of liquor potassæ, 1 in 4. Before doing this, the lips of the cervix should be gently squeezed between the blades of the speculum or of sponge-holder forceps. This seems to stimulate the cervical glands to pour out an excess of secretion, and imitates to a certain degree the process of massage. When all secretion has been drained away, the cervix should be painted twice a week with one of the following solutions: (1) iodised phenol (B.P.); (2) silver nitrate, 30–60 grs. to the oz., immediately followed by tincture of iodine (strong), silver iodide being formed and left behind; or (3) neoreargon 10 per cent, neoprotosil 10 per cent, or lunosol 10 per cent.

The application of any substances should be undertaken before the end of the fourth week of the inception of the disease. The length of

time needed to cure a case with bi-weekly treatments is about 10–12 weeks. If there is much scar tissue it may be necessary to dilate the internal os by the method described under the treatment of acute cervicitis.[1]

The resistant chronic case. The following methods may be employed in refractory cases: (1) Gentle dilatation of the external os by means of Hegar's dilator followed by painting with a strong antiseptic solution; (2) the insertion into the cervical canal of a gauze tampon soaked in tinct. iodi 3 parts and glycerine 1 part, and left *in situ* for six hours; (3) under an anæsthetic the cervical canal is dilated up to 10 Hegar. It is then superficially and gently scraped with a Volkmann spoon, and painted with silver nitrate 40–60 grs. to the oz.; (4) under an anæsthetic, dilatation up to No. 6 Hegar is followed by intra-uterine syringing with 5 cc. of acriflavine, 2 per cent in glycerine; (5) by the suction method, a fenestrated metal tube is inserted into the cervical canal, and rubber tubing is passed over that until it impinges against the cervix (see fig. 2904). A suction syringe of the Dieulafoy pattern is attached to the metal tube and the cervical discharge is thoroughly sucked out. This is followed by the application of acriflavine, 2 per cent in glycerine, to the canal; (6) diathermy, as elaborated by E. P. Cumberbatch and C. A. Robinson of St. Bartholomew's Hospital; (7) amputation of the cervix is seldom required but it may have to be undertaken if all the other measures properly carried out fail to rid the cervix of the gonococcus.

In multiparæ (Type 2) there is so often an indefinite history of acute or sub-acute endometritis and salpingitis, and experience has shown that the methods just described are of little or no avail. The treatment by dilatation of the cervix, followed by intra-uterine syringing as described before, may, however, effect a cure in a certain number of cases, the cultures becoming permanently negative when examined over a long period following cessation of all treatment, the menstrual periods becoming normal, and symptoms of salpingitis clearing up. If, however, infection of the cervix still persists in spite of all treatment, then operation involving removal of the infected tubes, or even of the whole uterus, must be considered.

Prognosis in Cervicitis. In the acute condition in nulliparæ the prognosis is good, and a cure can be effected in one to two months, or even more quickly if the treatment advised is carefully carried out. In acute cervicitis in multiparæ there is a tear and often considerable

[1] Bourne's method (*B.M.J.*, Jan. 1937) by means of a zinc pencil has proved successful in certain cases.

scar tissue, and the prognosis is not so good. It is much more difficult to clear out the cervical canal properly and to get good drainage, and the cure usually takes three to six months unless dilatation is employed.

In chronic cervicitis amongst nulliparæ the prognosis is good, though the treatment is more tedious and needs to be somewhat more drastic than in the corresponding type of acute cervicitis.

In multiparæ the prognosis of the chronic condition is not good, for although the discharge from the cervix appears to be healthy, gonococci can be grown on culture. Cultures will become negative after appropriate treatment, but only to become positive again when it is stopped. In this relapsing type of case there usually proves, on fresh and careful examination, to be an obscure history of deep pelvic trouble and very indefinite physical signs indicative of infected tubes. The history and signs have generally been so indefinite that the real source of infection—namely, a mild infection of the Fallopian tubes—has been missed

Endometritis, salpingitis, oöphoritis, pelvic cellulitis and peritonitis are dealt with in Volume II, Part X.

CHAPTER VI

Gonorrhœa in Female Children

It is not until one has worked in a V.D. clinic for some time that one realises the prevalence of gonorrhœa in female children. In an analysis of 650 consecutive cases in the Female Gonorrhœa Section of the V.D. Clinic of the London Hospital by the late Mr. Frank Kidd and myself, we found no less than fifty infected children (roughly 8 per cent). Most of the children were under eight years of age, whereas on the male side gonorrhœa in boys under the age of twelve is rarely seen, and then usually as the result of sexual precocity.

To determine the real source of infection in female children is a problem of some difficulty. It is possible that in a very few cases the vulva is infected at child-birth, while the child is passing through the infected maternal passage; but the large majority of gonococcal infections in female children undoubtedly arise from the promiscuous life of the poor—the communal use of the towel, soap, sponge, etc. The disease is also encountered in children of the well-to-do classes, but here it is met with sporadically, and is due in most instances to an infected nurse or servant. An important factor in infection is that the vulval secretions of the child appear to be lacking in those bactericidal qualities which characterise the vaginal secretions of adults, and this may account for the susceptibility of children to infection from external objects. Spread to the cervix is rare, but is met with in a few chronic cases and requires topical treatment. Urethritis is less common than in adults. Rare complications are arthritis, ophthalmia, inguinal adenitis, and proctitis (said to be a common complication in America). Peritonitis is almost unknown. Sub-acute pneumococcal peritonitis with a large collection of pus in the pelvis and lower abdomen may occur in children as a result of pneumococcal vaginitis. This is quite distinct from the acute diffuse pneumococcal peritonitis occurring in the course of a generalised pneumococcal infection, and is seldom met with in children.

Symptomatology and Signs of Vulvo-vaginitis. In acute cases the symptoms are severe pain between the legs (increased by walking), burning, increased frequency of micturition, and a vulval discharge.

In chronic cases, especially in the non-specific variety, the child may complain of nothing more than a slight itching which causes her always to be scratching the parts, and generally results in secondary excoriation and infection of the surrounding skin. When examining a child it is advisable to wear motor-goggles in case the child starts passing water into one's face. Examination is often very difficult, and patience and tact are required. If the child refuses to be examined there is nothing for it but to have her held down by two nurses, each one grasping an arm and a leg. The child must lie on her back with the legs held wide apart and flexed on the abdomen. A thick yellowish discharge is seen covering the labia, which are swollen, tender, and glued together. When separated, they reveal the vestibule and a hymen which is red and œdematous. Excoriations covered with crusts are often present on the skin of the perineum and thighs. In old-standing cases small superficial ulcers on the inner surface of the labia are seen, and even condylomata acuminata.

Diagnosis. This is made by finding gonococci in a film of the vulvo-vaginal discharge. In this respect the method differs entirely from that in adults, where vaginal smears are not searched for gonococci. All vaginal discharges in children should be strongly suspected of having a gonococcal origin, and should not be rejected as such until at least three careful film and cultural examinations have been made at several days' interval. Even in acute cases treated from the start, and also in chronic cases treated late, a stage may ensue where all signs of inflammation or purulent discharge are absent, and yet gonococci can still be identified in vulval and vaginal cultures. These cases are true "carriers" and probably account for school epidemics. Vulvitis can, of course, arise from other causes, as from uncleanliness, malnutrition, the acute specific fevers, thread-worms, and bacteria such as the colon bacillus, pneumococcus, and diphtheria and tubercle bacilli. Uncleanliness and parasites are the commonest causes.

Treatment of Vulvo-vaginitis. The treatment severely taxes the patience of the doctor and nurse, yet with perseverance there are few cases that will not finally yield to methods based on experience. In the first place, a determined effort must be made to examine all the members of the family. It is useless to treat one member of the family only, if other infected members remain untreated. The mother must be warned to provide the child with her own marked towel, soap, sponge, basin and chamber, and to see that the water-closet is wiped over with lysol 1 drachm to the ounce after the child has used it. If possible the child should have a separate bed.

Routine method. With the parts fully exposed, the vulva is dried out with mops of cotton wool held on sponge-holders. With wool twisted on Playfair probes and dipped in acriflavine 2 per cent in glycerine, all the surface of the labia, vestibule, hymen, and skin around the vulva is painted. After this has been done, the vagina is dried out with wool passed through the hymen on Playfair probes. The vagina is sponged out with 2 per cent acriflavine in glycerine, using a pipette and rubber teat, and the whole of its surface is then painted with the same solution. It is advisable to carry out the treatment daily, if possible, but if the acriflavine proves too irritant it should be used only two or three times a week, eucalyptus oil, 10 per cent in olive oil, being used on the other days. Usually, after about six applications, the discharge has diminished to a minimum quantity, and all pain and itching have ceased. The average time we found necessary at the London Hospital Clinic was four months. In these cases treatment was only given in the Out-Patient Department twice a week. The majority of cases cleared up in three to five weeks, but the figures were weighted with a number of resistant cases which took many months to cure.

"*Carriers.*" In a certain number of instances, although the patient appears to be perfectly healthy and there are no clinical signs of vulvovaginitis, cultures repeatedly show gonococci. The cure of this "carrier" type of case is difficult, and treatment may have to be pursued for many months before a successful result can be obtained. It is advisable to proceed as follows: Under an anæsthetic a tiny Cusco speculum is carefully introduced so as to avoid rupture of the hymen and yet permit exposure of the cervix. In some cases I have found the external os red and swollen, and have demonstrated gonococci in the cervical secretion. In these cases a few drops of iodised phenol or silver nitrate 20 grs. to the oz. should be applied to the external os. This is done weekly, and a cure brought about. In others it is impossible to demonstrate any cervical involvement, and the cause of this persistent infection remains obscure. It is possible that the gonococcus lives in some crypts in the vagina which have not been touched by the antiseptic. Perseverance for some months with the vulval and vaginal painting (silver nitrate 20 grs. to the oz. and 1 per cent lactic acid) has resulted in cure.

Other methods. Norris quotes Van Girson's treatment, in which a medicine-dropper is used to introduce into the vagina 3–4 drachms of 1 in 4000 mercuric chloride solution made up in isotonic saline, this being performed several times, repeatedly being sucked in and out of the dropper. After this has been thoroughly carried out, the washing is

sucked up into the dropper, centrifugalised, and examined for gonococci. The vagina is then dried out and painted with 5–10 per cent silver nitrate in water. Twenty-four hours later a second lot of washings is obtained and gonococci are looked for. The silver nitrate acts as an irritant, and second washings are therefore more likely to contain gonococci. This is a useful method of treatment in resistant cases, and also acts as a test for cure towards the end of a course of treatment.

A new treatment has been described by Nabarro and Signy (*Lancet*, 1935, March 16th). It is known that *oestrin* produces epithelisation of the vaginal mucous membrane in virgin rats and mice, and as the result of this observation the administration of menformon has been recommended. The dosage advised is six tablets a day (each 1000 international units). At the same time a daily douche of iodine, 1 drachm to the pint of water, or 1 in 150 chloramine-T solution is given, vaginal packs of gauze strips soaked in glycerine and flavine or glycerine and protargol, the latter being the most satisfactory, being left in for twenty-four hours. By this method the average length of treatment is reduced, and in some cases relapses have been cured by the administration of oestrin alone. It was found that the local discharge rapidly cleared up, and microscopically the results were very striking The general health was excellent and weight was gained. In some instances there were spasmodic pains in the abdomen, and even cyanosis. Enlargement of the breasts also occurred, but subsided immediately the oestrin was stopped. There was no enlargement of the genitals. but sometimes there was a slight growth of pubic hair. Urethritis was present as a complication in 10 per cent of the cases reported. Probably in many cases gonococcal urethritis is present, but clears up by natural resolution in the course of one to six weeks.

It is better to employ routine methods of urethral treatment in addition to the vulval and vaginal treatment. This is carried out once a week by passing into the urethra a tiny Playfair probe covered with a wisp of cotton wool dipped in silver nitrate solution, starting with 5 grs. and working up to 20 grs. to the ounce.

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SECTION 2

SYPHILIS

by

SURGEON-COMMANDER J. B. CRAWFORD, R.N.

CHAPTER I

PATHOLOGY

SYPHILIS may be described as a specific disease caused by the entrance into the body of the *spirochæta pallida*, often called the *treponema pallidum*. It is proposed in this article to refer to the organism as spirochæta pallida, which was the original name given to it by its discoverer, Schaudinn, and the one by which it is commonly known in this country. It is generally accepted that there must be an abrasion in the skin or mucous membrane before the organism can effect an entrance, though some authorities deny that a surface lesion is necessary.

The spirochæta pallida is a very slender microscopic organism, shaped like a spiral. It is about 0·25 microns in thickness and varies in length from 4 to 20 microns or even more, the number of spirals varying with the length of the organism. The average length is about one and a half times the diameter of a red blood cell, i.e. 10 microns, and this length contains about eight spirals.

On examination with dark-ground illumination, the fresh specimen will show a dead white and very active organism. This activity is confined to the spirochæte itself. Its progress across the field of vision is very slow, much energy being expended for the amount of positional change. The motility of the organism is very characteristic and has three definite essentials:

(1) A rotary movement similar to a corkscrew.
(2) Lateral or side-to-side movement. The spirochæte may bend on itself at an acute angle.
(3) A closing and extending of the individual spirals.

The spirals themselves never become straightened out even when the organism is dead, as will be noted in stained specimens.

That, pathologically, there are different strains of the spirochæta

pallida has been maintained by some workers in an effort to explain why certain cases are more virulent than others and why the organism causes, for instance, cardio-vascular lesions in one person and cerebral syphilis in another. So far, no accurate proof has been produced that this is so. It is generally accepted that personal idiosyncrasy to a large extent determines the seat of the lesion.

Recent researches suggest that the spirochæta pallida can assume some other form, possibly a minute granule, which, after an indefinite period, can, under favourable conditions, develop again into its original state. This theory would partly explain the disappearance of spirochætes and the latent periods in tertiary syphilis; also it would throw light on some of the curious phenomena of congenital infection.

Incubation. The period of incubation varies considerably. It may be as short as twelve days or as long as three months, but it is usually about four weeks. During this period the spirochæte multiplies and the toxins thereby produced cause irritation of those tissues with which they are in contact. The result is a peri-vascular round-celled infiltration. This local cell proliferation soon undergoes necrosis and at the end of the incubation period a chancre or primary sore appears at the site of inoculation. During this incubation the organisms are chiefly in the area surrounding the seat of infection and in the lymphatic glands draining it. They are most numerous at the point of inoculation and by the irritation of their toxins determine the position of the sore.

The Primary Sore. The chancre or primary sore, whether genital or extra-genital, is usually indurated, though sometimes it will be noted that a small pin-head erosion of mucous membrane will reveal, on dark-ground illumination, numerous typical spirochætæ pallidæ. The lymphatic glands draining the area become enlarged. They are painless and each gland may be felt distinct from its neighbour. Gland puncture usually reveals the presence of the causative organism. Unless treated, the sore increases in size and in a period of one to two months the secondary lesions make their appearance.

Secondary Manifestations. The secondary stage is one of general infection and is characterised by skin lesions, general adenitis, some malaise, anæmia, mucous membrane changes, and a rise of temperature.

Skin Lesions. The syphilitic rash may be truly described as polymorphic in character. It is, as a rule, first noticed on the trunk, gradually extending to the limbs and face and even to the palms of the hands and the soles of the feet. It may be macular, papular, papulo-squamous, pustular, or even rupoid in appearance. In areas which tend to become moist, condylomatous growths may appear. The

colour of the rash is usually a dull red. It has been described as coppery, but when this is noted it is probable that the rash is fading. In a severe case it will be found that these coppery spots will last for months before finally disappearing. If a small blister is made on a portion of the rash, the spirochæta pallida can, as a rule, be demonstrated in the resulting serum.

General Adenitis. All lymphatic glands show a tendency to increase in size. These are painless and feel like small masses of rubber under the skin.

Malaise. This is not a constant symptom, but the patient usually feels "out of sorts" during the onset of the skin lesions and has some rise of temperature.

Anæmia. This is a fairly constant symptom and in severe infections the red cells may be as low as two and a half million.

Mucous Membrane Changes (see also page 5022). These are usually manifest on the buccal mucous membrane associated with ulceration of the tonsils and soft palate. The epithelial cells become swollen, producing a whitish appearance, and tend to desquamate. The area affected is circular in outline with a red marginal zone. In severe cases ulceration takes place giving rise to acute stomatitis. When the tonsils are affected they become swollen and ulcerated, often leaving a serpiginous scar on healing.

Between the primary and secondary stages the Wassermann reaction of the blood, which has hitherto been negative, becomes positive. This takes place about two weeks after the appearance of the sore. During this period, if treatment is properly administered, there is a reasonable probability of cure without the disease ever reaching the secondary stage. The earlier the treatment is started the more certain the elimination of syphilis becomes.

It is a peculiar characteristic of this disease that, once the blood Wassermann becomes positive, the patient is rendered immune to further primary lesions, whereas, prior to this, inoculation with the spirochæta pallida will produce a primary lesion. This is often seen in the case of contact chancres on the prepuce or where a penile sore lies in contact with the thigh.

During the secondary stage there is an enormous increase in the number of spirochætæ pallidæ all over the body. The manifest symptoms are chiefly due to the irritation caused by the vast numbers of these organisms which have found their way to the skin, mucous membranes, lymphatic glands, etc.

Tertiary Stage. The character of the disease now changes. Secondary lesions resolve and there comes a period of latency in which there are no apparent manifestations. This may last from a few months to

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Tertiary Stage. The character of the disease now changes. Secondary lesions resolve and there comes a period of latency in which there are no apparent manifestations. This may last from a few months to

many years, and some authorities maintain that the disease in a certain percentage of cases becomes spontaneously cured without anti-syphilitic treatment.

There is no hard and fast dividing line between the secondary and tertiary stages. Sometimes tertiary lesions follow on, or even overlap, the secondary.

The spirochætæ pallidæ which were so numerous throughout the body now begin to disappear Probably they are destroyed by the protective defences set up. There are, however, a certain number left which succeed in forming a nidus in any organ or tissue of the body where they lie dormant.

The reaction of the tissues to the organisms causes the production of a gumma or gummatous infiltration. This consists of a mass of endothelial cells and newly-formed blood-vessels. The walls of these vessels become involved and undergo a process known as endarteritis obliterans, thus curtailing the blood supply to the growth, which, if small, is replaced by fibrous tissue, or if large, usually undergoes necrosis, thus producing the typical lesions of tertiary syphilis which may be described as those of degeneration.

Osler's statement: "Know syphilis in all its manifestations and relations and all other things clinical will be added unto you," is certainly true of this stage of the disease.

As previously stated, no organ or tissue is immune from attack, from the brain to the skin. According to the part infected so the vast symptomatology of this stage of the disease is accounted for. In fact, there are few, if any, symptoms which cannot be simulated, from a simple granuloma of the subcutaneous tissue to the highly complex pathology of general paralysis of the insane.

A brief summary of the manifestations occurring in the tertiary stage will now be given:

The fundamental principle of tertiary syphilitic infection in whatever organ it may attack is, first, an irritation producing a proliferation of cells, and, second, a degeneration due to the destruction of the vessels supplying these cells—endarteritis obliterans.

The spirochæta pallida is carried throughout the body by the blood stream and may obtain a nidus in any part; often an injury may determine the seat of infection. Having obtained a habitat where it can exist in comparative safety from destruction by the defensive mechanism of the body it starts on its fell career of gummatous infiltration.

It is quite possible that the characteristic organism may undergo a change which renders it more or less immune from destruction.

Gummata of the Skin. These may occur on any part of the skin. They may be multiple and be distributed over a large area, or there may be only a single gumma (fig. 2906). A common place is the inner part of the leg in its upper third or the inner aspect of the knee (fig. 2907). The skin, for want of adequate blood supply, becomes necrotic, leaving an ulcer, which, unless treated, extends laterally and is very slow to heal. Reference to gummata of the skin will be made later when diagnosis is being discussed.

Gummata of Mucous Membrane. These are most common in the

Fig. 2906.—Diffuse gummatous infection of the back.

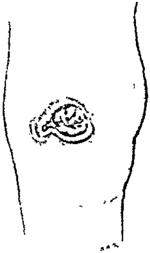

Fig. 2907.—Gumma of the skin and subcutaneous tissues, involving the inner aspect of the knee.

Fig. 2908.—The facies of congenital syphilis.

naso-pharynx, tongue, and rectum. The ulceration is usually irregular, leaving snail-track scars of fibrous tissue on healing, these being liable later on to cause stenosis of the larynx and the rectum. Gummata of the nose usually encroach on the bones and cartilages of that organ, giving rise to the well-known flattening which is a common feature of congenital syphilis (see fig. 2908).

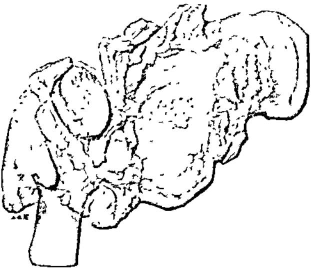

Fig. 2909.—Charcot's disease of the hip joint.
(*Dept. of Pathology, Univ. of Birmingham.*)

Fig. 2910.—Charcot's disease of the knee joint.
(*Museum, R.C.S.*)

Gummata of Periosteum and Bone. Most gummata are more or less painless, but those of periosteum and bone are, as a rule, painful.

The sequela of a gumma is either a fibrosis or a necrosis, but in periosteum and bone, if necrosis does not take place, the gummata ossify, producing nodes which can easily be felt in such bones as the tibia and clavicle (fig. 2911).

On X-ray examination of these bony tumours it will be noted that

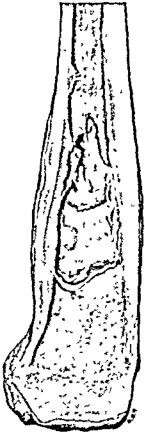

Fig. 2911.—Gumma of bone. Gumma of the medulla of the tibia, showing an area of necrosis with thickening of the shaft and slight periostitis.

(*Dept. of Pathology, Univ. of Birmingham.*)

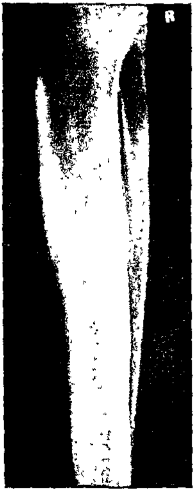

Fig. 2912.—Syphilitic ostitis of the tibia. The cortex is thickened and the medullary space diminished by production of new sclerotic bone. The process is a slow inflammation, granulation tissue is formed in the deeper layers of the periosteum and in the Haversian canals. Local rarefaction can be recognised in the early stages, but new bone gradually replaces the granulation tissue and the characteristic picture is that of sclerosis with thickening of the shaft.

(*H. Cecil Bull, Southend General Hospital.*)

the new bone formation is very dense, a point of considerable diagnostic importance (fig. 2912).

Reference may here be made to a peculiar arthritic condition which may occur in syphilis, namely Charcot's joint (figs. 2909 and 2910). This is not due to gummatous infiltration of the surfaces forming the joint, but to a destruction of the trophic nerves supplying it. Pain in this lesion is absent.

Cardio-vascular Infection. This condition probably has a greater mortality than any other syphilitic lesion.

As the syphilitic organism finds its way from the primary sore through the lymphatics into the blood stream, there to be circulated to all parts of the body, it is quite logical to assume that, in the minute blood-vessels such as arterioles, vasa vasorum and capillaries, the infective material may become attached to the vessel wall and there start the usual cycle of irritation, cell proliferation and degeneration. The irritation produces an arteritis or phlebitis, eventually leading to malnutrition of the part involved. In the brain, for instance, a monoplegia may be the result.

Later, when the tertiary stage becomes manifest, the irritative process is replaced by a gumma and subsequent fibrosis, and the disease then assumes a more serious aspect, especially when the aorta, coronary arteries and valves of the heart become involved, giving rise to aneurysm, myocardial degeneration, valvular incompetence, and the host of symptoms caused by arterial degenerative changes.

Meningo-vascular Involvement. It is easy to imagine that when the " meningo-vascular system " becomes infected, a vast number of apparently conflicting symptoms may arise according to the particular part affected, such as the meninges, the base of the brain or other important cranial structures. The symptoms are due to pressure, thrombosis, and gummatous infiltration.

Neurosyphilis. This may be described as a syphilitic infection of the parenchyma of the brain and spinal cord. It has been referred to as a parasyphilis and sometimes as the quaternary stage. The result of such an infection is indeed grave, leading as it so often does to insanity, paralysis and death. unless treatment is forthcoming.

It is a curious fact that neurosyphilis usually develops in those cases in which obvious external secondary or tertiary lesions have been more or less absent. Indeed it is very rare to find external tertiary manifestations in a victim of this form of syphilis.

The parenchyma of the brain and spinal cord, like other parts of the body, requires a blood supply, and it is in the fine capillaries and lymph channels of the brain substance that the syphilitic virus starts its work of degeneration, so that neurosyphilis can be regarded as a tertiary manifestation.

CHAPTER II

Diagnosis

Since the researches of Schaudinn, who identified the causative organism of syphilis, and the investigations of Wassermann, who discovered the specific reaction of the blood associated with his name, the diagnosis of syphilis has been rendered comparatively simple, though difficulties still arise in a certain percentage of cases.

Examination of the Primary Sore. The primary sore is usually regular in outline with a shelving edge, a necrotic base, and an area of

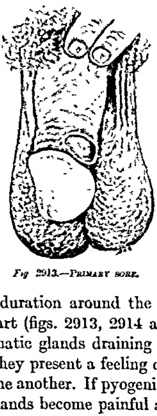

Fig 2913.—Primary sore.

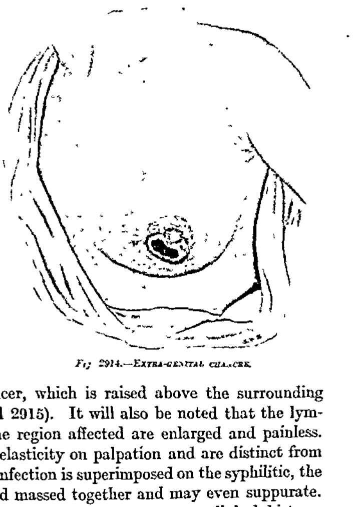

Fig. 2914.—Extra-genital chancre.

induration around the ulcer, which is raised above the surrounding part (figs. 2913, 2914 and 2915). It will also be noted that the lymphatic glands draining the region affected are enlarged and painless. They present a feeling of elasticity on palpation and are distinct from one another. If pyogenic infection is superimposed on the syphilitic, the glands become painful and massed together and may even suppurate.

Care should be taken in obtaining an accurate clinical history. Note should be made of the period of incubation, previous infection, and any treatment which may have been applied to the sore, the

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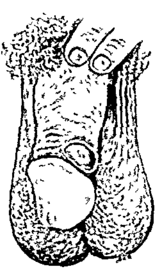

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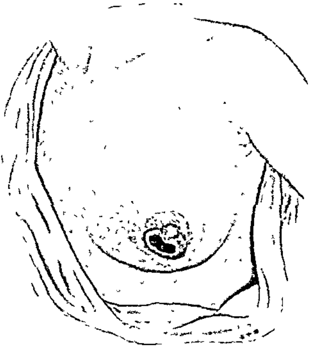

Fig. 2914.—Extra genital chancre.

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Care should be taken in obtaining an accurate clinical history. Note should be made of the period of incubation, previous infection, and any treatment which may have been applied to the sore, the

presence or absence of rash, time of onset, sore throat, etc. Considerable tact should be used if a true history is to be obtained.

In the primary lesion, the causative organism is, as a rule, easily demonstrated in the serum taken from the chancre. One of the best ways to obtain this fluid is, after cleaning the sore with normal saline, to grip the edge firmly between the finger and thumb, and then to puncture the part under tension in several places with the point of a fine sterile needle, not going deep enough to cause hæmorrhage. In a few minutes small drops of serum will be seen to exude. These are collected in a fine capillary tube which can be hermetically sealed in the flame of a spirit lamp and be sent to a laboratory for examination, or be expressed directly on to a glass cover-slip with a thin smear of vaseline round the edge. Care should be taken that no air bubbles are contained in the serum so expressed. This cover-slip is carefully lowered on to a glass slide and pressed evenly with a needle to give a thin

Fig. 2915.—PRIMARY CHANCRE OF THE LIP (*Drawn from a photograph in Mr. Cecil P. G. Wakeley's Collection.*)

and even distribution of the fluid. It is now ready for examination by the dark-ground illumination. When present, the spirochæta pallida is easily demonstrated by this method of procedure.

In secondary manifestations, the organism can frequently be discovered in the rash by raising a blister and examining the resultant serum. It can also be obtained in the fluid from gland puncture. In tertiary lesions, it has been found occasionally but only after prolonged and careful search.

The characteristic movements, size and regularity of the spirals and the dead-white colour of the organism makes its recognition certain. The spirochæta pertenuis which is the cause of yaws is very similar to the pallida. It is doubtful if these two organisms can be differentiated from one another under the microscope; indeed, some authorities claim that they are identical. Two other spirochætes may be mistaken for the pallida, viz. the spirochæta gracilis and the spirochæta microdentum. The spirochæta gracilis is thicker than the pallida and its movements across the field of vision are much more rapid. The spirals are coarser and it is not dead white in colour. The spirochæta microdentum which is occasionally found in decaying teeth is shorter and the spirals are shallower than those of the pallida; furthermore it is easily stained. The other spirochætes which may be encountered have entirely different characteristics and are unlikely to be confounded with the specific organism of syphilis.

Demonstration by Staining. The spirochæta pallida is very difficult to stain, but Giemsa's stain and Fontana's silver stain may be used with success. The organisms can also be distinguished by the indian ink film.

There is a modification of Fontana's method which often gives good results and which is here noted in detail. The serum to be examined is placed on a microscopic slide and allowed to dry. It is then fixed for one minute in the following fluid:

Glacial acetic acid . . .	1 part.
Formalin (40 per cent) . .	20 parts.
Distilled water . . .	100 parts.

Drain this off and pour on a 10 per cent solution of tannic acid in distilled water. Heat the slide to the point of steaming for thirty seconds, wash in distilled water for thirty seconds, apply carbol fuchsin solution and heat to steaming point for a half to one minute, then dry. The slide is now ready for examination under a $\frac{1}{12}$*th objective.*

The Wassermann Reaction. This is of the utmost value in the diagnosis of syphilis when the disease has become established.

As previously mentioned, the W. R. does not become positive until the primary stage of syphilis is somewhat advanced. In early primary syphilis it is of no value from a diagnostic point of view. The W. R. begins to become positive in from 10–15 days after the appearance of the primary sore.

When, by means of its toxin, the syphilitic virus causes the destruction of body cells, lecithin and cholesterin are set free. These products of destruction stimulate the formation in the blood of certain substances which may be termed Wassermann bodies, and it is the presence of these that the W. R. demonstrates, not the presence of true antibodies, as is the case in other complement fixation tests. It is, therefore, not surprising that cases which are not syphilitic occasionally show a positive reaction. As a rule, these positive reactions are not permanent, for, if the test is performed two or three weeks later, a negative result may be obtained, presumably when the condition giving rise to the Wassermann bodies has resolved.

Clerical and technical errors in the laboratory and elsewhere may also account for some of the positive results.

It would be a grave mistake to presume that every case of positive W. R. is the result of syphilitic infection, without having some other confirmatory evidence to support such an assumption.

Of late, *precipitation tests* have been introduced such as the Kahn, Sigma, Sachs Georgi and Vernes as alternatives to the W. R. These tests, although accurate in their results, have not so far succeeded in ousting the W. R. from pride of place in the diagnosis of syphilis. In

doubtful cases two or more different sero-diagnostic methods are of value. If such tests are carried out the error will probably not be more than 3 per cent.

DIFFERENTIAL DIAGNOSIS

(1) *Chancroid.* This is a slow-healing sore usually affecting the genitals and is due to venereal infection. The incubation period is a few days instead of weeks. The typical induration is absent, the sore is irregular in outline, and the edges are undercut. It is considered that the causative organism is the bacillus of Ducrey. Examination of the serum fails to demonstrate the spirochæte of syphilis, and a common sequela is suppuration of the lymphatic glands which drain the affected area.

(2) *Herpes Genitalis* This is a fairly common condition and is usually found on the glans penis or vulva. It starts as typical herpetic vesicles which often coalesce leaving an irregular sore with punched-out edges. Absence of spirochætes, induration, and the typical adenitis are the diagnostic points.

(3) *Pyogenic Ulceration.* This condition is usually due to trauma combined with a want of cleanliness. The history of the condition, and the absence of the spirochæta pallida and of typical induration will usually render the diagnosis clear. while if the lymphatic glands be involved they are painful, massed together, and often suppurate.

(4) *Scabies.* The skin covering the genitals is a common seat for scabitic infection. Scratching may impose a pyogenic infection on the burrows of the acarus and simulate a syphilitic sore. The demonstration of the acarus and its presence in other parts of the body with the absence of typical syphilitic findings usually clear up the diagnosis.

(5) *Acute Balanitis with Mucous Erosion.* This is a septic condition of the prepuce and glans. usually due to phimosis and want of cleanliness Purulent discharge and inguinal adenitis are present, accompanied by pain. Various spirochætes may be found in the excretion, such as spirochæta refringens and spirochæta balanitidis, but these are easily distinguished morphologically from spirochæta pallida.

It is necessary to remember that syphilitic infection may be superadded to any of these conditions and so confuse the diagnosis. Careful examination of the exuded serum for spirochæta pallida, the W. R. of the blood and the effect of arsenical treatment on the sore should settle the diagnosis.

In the differential diagnosis between syphilis and other skin lesions the W. R. is invaluable, as the syphilitic rash may simulate any other skin eruption. Too much reliance should not be placed on the colour,

distribution and character of the rash. The presence of a primary sore or the resulting scar, the general adenitis, and the anæmia will help considerably in diagnosis, while a positive W. R. will render it almost certain.

COMMON MANIFESTATIONS OF THE TERTIARY STAGE

As tertiary syphilis is essentially a disease of the vascular system and is liable to attack any organ or tissue of the body, so the symptoms and diagnostic signs vary to a great extent according to the part or parts affected. A few of the commoner manifestations may be mentioned:

Skin and Subcutaneous Tissues. About one-third of all tertiary lesions attack the subcutaneous tissues. Trauma often determines the site. The condition may be: (*a*) papular, (*b*) nodular, or (*c*) gummatous. The two former attack the true skin, while a true gumma includes the subcutaneous tissues as well.

As a rule, the *papular* type starts as a single papule which soon becomes surrounded with other papules, the process extending until quite a large area is involved.

In the *nodular* type hard raised nodules, reddish-brown in colour, appear in the skin. If close together they coalesce, eventually leaving a dark brown pigmented scar. Gummata start in the subcutaneous tissues and then invade the skin. They usually form a large, round, painless mass, which frequently breaks down leaving a typical punched-out ulcer with a sloughing base.

A very common site of involvement is the upper third of the leg, in contra-distinction to a varicose ulcer which is usually found on the lower third.

Tertiary syphilitic infection of periosteum and bone has already been mentioned.

Gummata of Tonsils. As a rule, only one tonsil is affected at a time. The condition is usually painless in spite of extensive destruction of the gland.

Perforation of the soft palate is not uncommon in untreated cases, and leucoplakia of the tongue and buccal mucous membrane is also a condition found in tertiary syphilis.

Gummata of the Testicle (see fig. 2916). This organ becomes hard, heavy and swollen. There is complete loss of testicular sensation and function; as a rule, pain is absent. The lesion is due to fibrous tissue replacing the gummatous infiltration in the parenchyma. It is frequently associated with hydrocele.

Cardio-vascular Syphilis. Cardio-vascular involvement is one of

the most serious disabilities produced by syphilis. Every case of this disease must have a very careful examination, and, if there be the slightest evidence of cardio-vascular involvement, it is of the utmost importance to initiate anti-syphilitic treatment without delay.

Briefly, the symptoms of tertiary syphilis are those which are produced by arterial degeneration and by the consequent loss of adequate blood supply to the organ or tissues involved.

The symptoms of gross involvement of the cardio-vascular system are those of aneurysm, valvular inefficiency, muscular degeneration, and high blood-pressure, and when the arteries of the meninges become involved, severe headache, convulsions and apoplexy usually result.

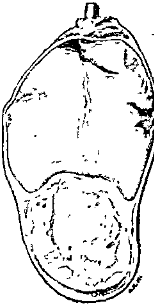

Fig 2916.—GUMMA OF THE TESTIS WITH SECONDARY HYDROCELE. IN THIS SPECIMEN THE FLUID IN THE SAC HAS BEEN COAGULATED IN THE PROCESS OF STAINING. HYDROCELE IS A COMMON ACCOMPANIMENT OF GUMMA OF THE TESTIS. (*Dept. of Pathology, Univ. of Birmingham. By kind permission of Professor Haswell Wilson.*)

Syphilis of Brain and Cord. (*a*) Meningo-vascular syphilis, and (*b*) Parenchymatous syphilis or Neurosyphilis. There is no hard and fast dividing line between these two as far as symptoms are concerned. As the brain is enclosed in a rigid bony box, leaving little room for expansion, one can easily realise that when a syphilitic meningitis begins, apart from the damage done by the spirochæte itself, the exudate caused by the inflammation increases the intra-cranial pressure, and this pressure acting on important structures gives rise to a variety of symptoms. Later, when arterial degeneration takes place, with the consequent loss of nutrition, a very different picture is produced. Indeed it would be extremely difficult to describe the complete symptomatology of cerebral syphilis.

When the parenchyma of the brain and spinal cord becomes involved, one may classify the symptoms into three groups :

(1) Changes of sensation, e.g. hyperæsthesia, anæsthesia, deafness, etc.
(2) Mental disorders, e.g. loss of memory, delusions, mania, depression, etc.
(3) Paralytic changes, e.g. loss of function of voluntary and involuntary muscles.

The three outstanding types of neurosyphilis are:

(1) Tabes dorsalis or locomotor ataxia, in which the parenchyma of the spinal cord becomes involved.
(2) General paralysis of the insane, which affects the brain substance.
(3) Tabo-paresis, which affects both brain and spinal cord substance.

Mention must be made of the changes in the cerebro-spinal fluid which take place when meningo-vascular syphilis and neurosyphilis are present.

The normal cerebro-spinal fluid is a clear colourless fluid having a specific gravity of about 1006 and a slightly alkaline reaction. In this fluid are traces of globulin, glucose and sodium chloride. A few lymphocytes are present, about 3–5 per c.mm. The pressure of the fluid in the canal is slight and it drains away slowly on puncture.

When neurosyphilis develops, most of these substances are increased, as is also the pressure. The cellular elements may reach 200, or even more, per c.mm.

A valuable aid in the diagnosis of cerebral syphilis is Lange's test which depends on the precipitation of a colloidal gold solution in certain dilutions by the pathological amount of protein in the cerebro-spinal fluid. This solution, which is red in colour, is added to test-tubes containing the fluid mixed with normal saline in increasing dilutions. If complete precipitation takes place, the resultant fluid is colourless. If no precipitation occurs, there is no change. Between these two extremes the colour varies from pale grey-blue to purple. Furthermore, this test is of value in differentiating between tabes and general paralysis of the insane. The former, showing only a slight change of colour in the stronger solutions, reaches a maximum and then gradually changes to normal again, commonly called a *luetic curve*, while the latter shows complete precipitation in the stronger solutions, gradually becoming normal again as the fluid becomes more and more dilute. This is known as a *paretic curve.*

The blood-Wassermann is not so reliable in neurosyphilis as it is in the systemic disease. Up to 10 per cent of cases may show a negative result. However, the Wassermann reaction of the cerebro-spinal fluid is practically always positive when neurosyphilis is present. It is a fairly common experience to find a blood-Wassermann reaction negative and the cerebro-spinal fluid reaction positive.

As in cardio-vascular syphilis, it is of the utmost importance to make an early diagnosis so that treatment can be instituted with the least possible delay, as damaged brain substance *cannot* be replaced and the result of such damage is permanent.

CHAPTER III

Congenital Syphilis

If a woman becomes pregnant about the same time as she is infected with syphilis and does not receive treatment, the disease is conveyed to the fœtus which usually dies in utero. In other words, primary or secondary syphilis in the mother about the time of her conception is invariably fatal to the offspring. When the disease has reached the late tertiary or a latent stage, healthy children are often born. The older the infection in the mother, the more likely is the child to live.

It is generally accepted that the infection of the fœtus takes place in the vast majority of cases through the chorionic villi, but it would be wrong to assume that such is always the case. Occasionally, direct paternal infection may be the cause via the spermatozoa. It is difficult to see how a spermatozoon could contain even a single spirochæte in its substance and be capable of impregnating an ovum. Possibly in such cases the organism has become altered to some dormant form such as a spore. The same theory may hold good for an infected ovum.

When paternal infection is to blame and the mother is not syphilitic at the time impregnation occurs, it commonly happens that she becomes infected by the fœtus and contracts the disease without a primary stage.

It has been claimed by some authorities that a syphilitic child may be born without having infected the mother during pregnancy, and that later, when nursing the child, she may develop a primary sore on the nipple, due to direct inoculation.

Colles' Law. Colles stated in regard to syphilis that: "A child born of a mother who is without obvious venereal symptoms and which, without being exposed to any infection subsequent to its birth, shows this disease when a few weeks old, will infect the most healthy nurse, whether she suckle it or merely handle and dress it, and yet this child is never known to infect its own mother even though she suckle it while it has venereal ulcers of the lips and tongue."

Colles considered that this was due to the mother developing a protective immunity when the child was in utero.

The law still holds good, but not for the reason he assumed. It has now been proved that, once the mother has become infected with syphilis and the blood-Wassermann reaction has become positive, she cannot again be infected with the disease until that attack has been cured.

The infected woman frequently shows very little evidence of syphilis during her pregnancy, and it is a common experience to find the W. R. negative in such cases. Various theories have been advanced to account

Fig. 2917.—CHILD WITH INHERITED SYPHILIS, SHOWING RADIATING SCARS AROUND THE MOUTH.

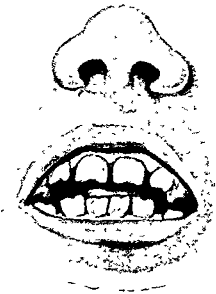

Fig. 2918.—HUTCHINSON'S TEETH.

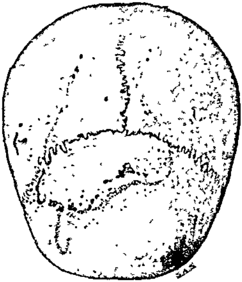

Fig. 2919.—GUMMATOUS OSTEITIS OF THE SKULL, SHOWING THE FORMATION OF A SEQUESTRUM.

for this curious anomaly, but without much success. A possible explanation may be that the chorionic ferments prevent the reproduction of the spirochætes and so render the disease latent.

A considerable amount of research work will be necessary before

some of the curious phenomena occasionally found in pregnant women are explained.

The effect of syphilis on the child, as has been pointed out, varies with the age of the disease in the mother. It is only when the infection has reached the later stages that a child may be expected to survive. It may be born with secondary syphilis, and show the usual manifestations of that stage. If it survives, it develops some of the stigmata, such as prominent frontal eminences, saddle-shaped nose, radiating scars from the mouth (see fig. 2917), Hutchinson's teeth (see fig. 2918), sabre-shaped tibiæ, gummatous osteitis of the skull (see fig. 2919), and many other conditions which are more or less peculiar to congenital syphilis. Later, about the time of puberty, the central nervous system may become involved.

In making a diagnosis, the W. R. of both the mother and the child should be ascertained, and in doubtful cases a flocculation test should also be made.

CHAPTER IV

Treatment of Syphilis

Before the introduction, by Erlich, of the arsenical treatment for syphilis, mercury in some form and potassium iodide were practically the only drugs used to combat the disease.

It is very doubtful if the majority of the cases were ever really cured. To a large extent the disease was kept in a latent condition and, as the manifestations were not obvious, cure was assumed. When the Wassermann reaction and such tests became a routine for the purpose of following the progress and determining the cure of syphilis, it was soon discovered that the assumption of cure in the older cases treated by mercury was not justified.

The argument that the time taken to cure syphilis by mercury was sufficient for the patient to become immune to further attacks was fallacious. It has now been proved that once the disease has been contracted no further fresh infection can take place until the original attack has been cured, and, further, that one attack does not give immunity though it may modify the signs and symptoms of a subsequent inoculation.

Arsenic in the Treatment of Syphilis. Erlich's idea was to produce a substance which would be specific for the destruction of the spirochæta pallida and at the same time cause no damage to the body cells or tissues. In salvarsan or " 606 " such a drug was produced. This is an arsenical compound and was his 606th attempt to obtain such a drug as he was seeking. While this substance is poisonous to animal life in certain concentrations, it has been found to have a marked destructive effect on the spirochæta pallida in dilutions that were innocuous to the human organism.

There are several modifications of Erlich's original drug, such as novarsenobenzol or " 914," sulpharsenol, silver salvarsan and many others, which produce fewer toxic effects but which still retain the therapeutic value of the original production. Some of these are used intramuscularly, others are for intravenous injection.

Triparsamide is a more modern preparation. It has not the spirochæticidal effect of the salvarsan group, but has been found to be of considerable value in the treatment of neurosyphilis. The use of this drug will be mentioned later.

Bismuth in the Treatment of Syphilis. This drug came into general use for the treatment of syphilis about 1921, following the researches of Sazerac and Levaditi who demonstrated its value.

Bismuth is by no means as potent a spirochæticide as arsenic, but that it does kill the organism may be demonstrated by the fact that in about ten to twelve days spirochætes disappear from a primary sore when bismuth alone is used, whereas the disappearance of the organism occurs in a few hours after a dose of an arsenical preparation. It is of great value as an adjunct to arsenic and, being practically non-toxic, can be used in cases of intolerance to that drug. It is administered in the form of intramuscular injections.

There are many bismuth preparations on the market, usually bearing trade names. They are supplied in aqueous solutions and oily suspensions, and also in the form of colloidal bismuth. The solutions are quickly absorbed but are frequently painful when injected. Probably the best form is an oily suspension which is slowly absorbed and has its curative effect spread over long periods.

Mercury and Potassium Iodide in the Treatment of Syphilis. These drugs have no spirochæticidal action *per se*, but are believed to cure syphilis by stimulating the body immunity and by assisting in the production of syphilitic anti-bodies. Mercury in itself is toxic, and care has to be exercised in the use of it.

Once syphilis has been diagnosed, the sooner the treatment is started the better chance there is of cure.

In treating the disease it is necessary not only to destroy the spirochæte itself and remedy the damage it has done but also to treat local manifestations and to attend to the general health of the patient.

Prior to the examination for the spirochæta pallida in the primary lesion. the sore should be dressed with normal or hypertonic saline, either hot or cold. Once the organism has been demonstrated, the chancre should then be treated with mild antiseptics such as calomel powder, lotio rubra, weak solution of mercurial salts, etc. If very septic, fomentations are of value and may prevent suppuration of the lymphatic glands draining the lesion. When the sore is situated under the prepuce and the patient has either acquired or congenital phimosis. it is well to make a dorsal slit in the prepuce to establish free drainage. or gangrene may be the result.

Skin and mucous membrane lesions should be kept clean and appropriate treatment applied.

The patient should avoid all excesses—dietetic, tobacco, alcohol

and sexual. In infectious cases sexual union should be prohibited for obvious reasons, and alcohol should be taken in strict moderation. Overwork and worry as well as want of a reasonable amount of sleep should be avoided, also strenuous exercise. In short, the general rules for good health should be observed.

In the fighting services of this country it has been customary to give intravenous injections of some form of novarsenobenzol or "914," in combination with bismuth and iodides, for the treatment of the majority of syphilitic cases. This treatment has stood the test of time and is convenient to use. Sulpharsenol has also been used to a large extent, with good results, when the intramuscular route is preferred.

A good deal of controversy has taken place from time to time as to what constitutes an adequate course of anti-syphilitic treatment, the tendency of late being to increase the number of doses rather than to lessen them. It should be pointed out, however, that syphilis should not be treated entirely in a routine manner, but each case should be considered separately and dealt with accordingly.

Dosage of "914." Experience shows that the optimum dose for a person of average weight is about 0·45 gm. given twice weekly. If this dosage is unduly exceeded there may be a corresponding increase of arsenical symptoms such as arsenical dermatitis, arsenical jaundice, etc.

Practically all the arsenic in a dose of "914" is excreted within seventy-two hours after injection, so that two doses a week can be given with safety in otherwise healthy patients. In ill-nourished persons the doses should be decreased or the interval between the injections lengthened.

A useful method of estimating the dosage for an adult is to allow 0·04 gm. of "914" to every stone in weight. Infants and children stand arsenical treatment fairly well unless they are marasmic and ill-nourished. Young's formula for dosage is fairly reliable, viz.:

$$\frac{\text{Age}}{\text{Age}+12} \times \text{Adult dose}$$

A careful examination of the patient should be made to eliminate any contra-indication to the administration of the drug.

Contra-indications to Intravenous Arsenic:

(1) Hypersensitiveness to arsenic.
(2) Jaundice.
(3) Cardio-vascular lesions, especially associated with high blood-pressure.

(4) Nephritis.

(5) Cachectic persons or those with advanced phthisis.

(6) Syphilis affecting the optic nerve, or gumma of the brain.

(7) Alcoholism.

In such cases "914" should be given in small doses and with great care, to avoid any untoward symptoms which might otherwise arise.

When "914" is given intravenously it quickly causes the death of any spirochæta pallida it may reach. The endotoxins from these dead organisms have a very irritating action on the surrounding tissues (Herxheimer's reaction).

It is easy to see that this irritation causes a good deal of reaction which, in such parts as the aorta, optic nerve, or brain, etc., may cause a dangerous exacerbation of symptoms; thus it is important in such cases that extreme care be exercised in the use of any arsenical preparation.

Complications arising from Intravenous Arsenic.

(1) *Anaphylactoid or Nitritoid Crisis.* This is comparatively rare, but when it occurs it does so immediately after injection. It is characterised by vasomotor disturbances, usually dizziness, rapid and disordered heart action, angio-neurotic œdema (often about the face and lips), hiccough, vomiting, and, in severe cases, coma. Mild symptoms are occasionally met with, such as an irritating cough or an attack of sneezing.

Treatment for this type of reaction consists of a hypodermic injection of ½–1 cc. of adrenalin, 1 in 1000, followed by the usual treatment for shock. Adrenalin given hypodermically prior to the administration of the arsenic will usually modify or completely prevent such symptoms.

(2) *Herxheimer's Reaction.* This usually occurs a few hours after the administration of the first dose of arsenic and is due to the destruction of vast numbers of spirochætes and the consequent setting free of their endotoxins. It is characterised by an intense rash all over the body, together with a rise of temperature, and usually occurs in florid secondary syphilis when the organisms are particularly numerous in the body. Therefore it is advisable to start a course of treatment with a small dose of arsenic. This is of the utmost importance when the cardio-vascular or meningo-vascular system is involved. Serious damage may ensue, or even death result, in such cases if there be a marked Herxheimer's reaction.

(3) *Acute Hæmorrhagic Encephalitis.* When this occurs it usually does so from two to five days after injection and is generally fatal forty-eight hours later. The condition is fortunately very rare.

When it occurs, strenuous measures should be taken at once. About 15-20 cc. of the cerebro-spinal fluid should be removed, venesection performed, removing up to 20 ounces of blood, and a hypodermic injection of 1–1½ cc. of adrenalin, 1 in 1000, given. If this treatment be carried out promptly it may save life.

(4) *Arsenical Dermatitis.* When this condition occurs it usually becomes manifest during the course of treatment, though sometimes it may be delayed until a week or so after the course is finished. It may vary from erythema of the skin to exfoliative dermatitis. Its onset is commonly preceded by general malaise with some rise of temperature, followed shortly by a rash which usually starts on the wrists and ankles and rapidly spreads to the limbs and trunk. When this condition is diagnosed, arsenical treatment should be stopped forthwith or complete exfoliation of the skin may result. Œdema of eyelids and lips is often associated with the more severe cases, and vesicles on the skin are common.

Treatment consists of the administration of sulphur. A 5 per cent ointment of ichthyol in lanoline should be rubbed into the skin all over the body once daily, and pil. ichthyol 3 grs. be given three times a day, or ½–1 drachm of sodium thiosulphate in water. Intravenous sodium thiosulphate is useful in doses of 0·5 gm. daily.

(5) *Arsenical Jaundice.* This may appear a few days after injection or may be delayed until some months have elapsed. Its severity varies from a mild attack of symptomless jaundice to the rare and severe condition known as acute or sub-acute yellow atrophy of the liver.

Some observers maintain that the simple jaundice sometimes seen during or after a course of arsenic is not due to the direct effect of arsenic on the liver cells, but to some intercurrent infection, the arsenic merely acting as a predisposing cause by lowering the general resistance of the body.

The attack of jaundice is usually mild and responds to treatment, which consists of saline purgatives, glucose, fat-free diet, and rest in bed. It is doubtful if sodium thiosulphate is of any value in this condition although some authorities recommend it.

(6) *Renal Damage.* This rarely occurs after the intravenous administration of arsenic if the kidneys are normal. Frequently a transitory albuminuria may be noted which rapidly clears up in a day or so, leaving no permanent damage to the organ.

Other complications due to arsenic, such as gastro-enteritis, stomatitis, pernicious anæmia, etc., are very rare and will not be described in detail.

Complications arising from Bismuth. These, which are few in number when due care is observed in the administration, and when a suspension rather than a solution is used, may be summarised as follows:

(1) *Stomatitis.* This is by far the most common complication due to bismuth. It starts in the gums, usually in unhealthy mouths, especially when dental caries is present, and spreads to the buccal mucous membrane. The first appearance is a blue line on the margins of the gums and this is often the only manifestation, no further lesion developing. This in itself is not a contra-indication to the use of the metal. When genuine stomatitis develops, the gums become tender, red and œdematous. Halitosis is usually present and salivation is increased. In severe cases ulceration takes place. The condition is somewhat similar to the effect produced by mercury.

Treatment consists of stopping the bismuth, keeping the mouth clean with mild antiseptic mouth-washes, and attention to the condition of the teeth.

(2) *Gastro-intestinal Disturbances.* These are rare and yield readily to careful dieting.

(3) *Phlebitis and Embolism.* This is due to injecting the bismuth preparation directly into a vein or artery. The exercise of due care will prevent such a catastrophe.

(4) *Abscesses at the seat of Injection.* This is usually due to lack of proper aseptic precautions at the time of injection. A sterile abscess may form if the bismuth is not absorbed, although this is a very rare occurrence.

(5) *Nervous symptoms* such as insomnia, neuralgic pains, and depression. These conditions are seldom noted, but when present yield to suitable sedative treatment.

TYPES OF SYPHILIS AND THEIR RESPECTIVE METHODS OF TREATMENT

Before deciding on the treatment of syphilis it would be well to classify the disease into different types, as the various types will require certain alterations or modifications of the treatment:

Type "A." Spirochætes positive. Wassermann reaction negative.
Type "B." Spirochætes positive. W. R. positive. Early secondary conditions.
Type "C." Late secondary and tertiary manifestations.
Type "D." Cardio-vascular and meningo-vascular syphilis, and neurosyphilis.
Type "E." Congenital syphilis.

Type "A." In treating this type, provided the case does not present idiosyncrasy or some other contra-indication to arsenic, and provided *the W. R. does not become positive, a large proportion of* cures may reasonably be expected.

It has been stated that one course of ten injections of "914" is sufficient to cure the disease in this early stage, and this has been proved in isolated instances by records of re-infection with syphilis in such cases. *Some attacks may be cured by one course but not all,* and several courses should be given in conjunction with bismuth before cure can be assumed.

The first course of treatment consists of ten doses of 0·45 gm. of "914" in a period of five weeks, preferably in conjunction with weekly injections of some form of bismuth, although bismuth has not the same value at this stage as it has later in the disease.

The number of courses required to cure Type "A." If the W. R. before, during, and after the first course of arsenical injections be *negative and remain so, at least three further courses of eight doses of* 0·45 gm. of "914," preferably combined with bismuth, should be given at three monthly intervals, and during this time the W. R. must remain negative. Treatment is then stopped and the W. R. is taken every three months for a period of two and a half years. If all these tests are *consistently negative, it is reasonably safe to assume a cure.* If at any time the W. R. becomes positive, the reaction should be repeated and *a flocculation test done as a control to eliminate the possibility of a* false positive. This being eliminated, treatment will have to start again *and be carried out as described for Type "B" cases.*

Preparation of the Patient for Intravenous Arsenic. The patient should be advised to take a mild purgative the night before the injection, and a light breakfast the following morning. The urine should be examined for albumen and bile, and about an hour before the injection the patient should take an ounce of glucose in water or lemonade. This is given in an attempt to fill the liver cells with glycogen and so prevent damage by arsenic. After the injection the patient should remain in bed for two or three hours.

Before every subsequent arsenical injection, the urine should be examined for albumen and bile, and the patient for dermatitis, jaundice, or any other complication which may arise.

Preparation of N.A.B. for injection. This should be done with great care. It is recommended that water recently distilled and sterilised should be used in the preparation.

"914" is obtained in small glass phials usually containing 0·3

gm., 0·45 gm., 0·6 gm. or 0·9 gm. The phial used should be examined carefully to ensure that there is no crack in the container, and no discolouration of the contents, which ought to be a light yellow powder showing no tendency to adhere to the glass. When exposed to oxygen "914" changes its colour to dark orange, then to brown, and finally becomes black. If there be any change of colour, the contents of the tube are toxic and should be discarded.

The amount of water used in dissolving "914." Multiply the amount in gm. of "914" to be given by twenty and the result will be the number of cc. of water required. Thus, if 0·45 gm. were to be given it would be dissolved in 9 cc. of water, if 0·6 gm. were the dose, the amount of fluid would be 12 cc.

If too concentrated a solution is given intravenously, thrombosis of the vein may occur, especially if the vein wall be much damaged by the needle.

After dissolving the "914" the solution should be passed through sterile filter paper to remove fine particles of glass which may fall into the tube when it is opened. Injection into a vein should be given as soon as possible after preparation to avoid oxidisation.

The *site of injection* is usually a prominent vein in the antecubital fossa. This area is well cleansed with iodine or ether. The patient sits in a chair and rests his arm on a sand-bag or small pillow placed under his elbow on an adjacent table. An attendant grasps the arm above the antecubital fossa and the patient then clenches his fist. This has the effect of bringing the veins into prominence. As a rule, this is all that is required to render the vein easy of access.

In patients with small veins, a good plan is to place the arm in hot water for a few minutes, as this has the effect of rendering the veins more prominent.

Technique for the administration of Bismuth. Bismuth is always used as an intramuscular injection. The gluteal region is the site of choice on account of its comparatively large muscular area.

Before starting a course of this treatment, buccal hygiene should be ensured, and during the course the mouth should be examined from time to time for oral sepsis or stomatitis.

The injection should be made once weekly in alternate buttocks, thus allowing each dose fourteen days for absorption.

One of the best preparations of bismuth is that made under the name of bicreol. This consists of very finely-divided bismuth metal suspended in a creocamph base. It is solid at ordinary temperatures and requires to be heated to about 100 degrees Fahrenheit prior to injection. Furthermore, it should be well stirred before filling the

syringe as, when the suspension is fluid, the metal tends to sink to the bottom of the container. Each cc. of this preparation contains 0·1 gm. of bismuth.

The course recommended consists of eight injections, the first two doses being of 1 cc. each, the next two of 1·5 cc. and the remaining four of 2 cc. each, giving a total of 13 cc.

The upper and outer quadrant of the buttock is the area usually selected for the injection. The needle used should be fairly strong. These needles are sterilised by boiling with the stilettes still inside them so as to ensure that there can be no mistake about their patency.

The buttock should be well cleansed with soap and water and then with iodine or ether, and a spot chosen where there is little likelihood of sepsis. The stilette is then removed and the needle plunged into the area with a firm thrust. It is left in this position for about ten seconds. If the needle be in a blood-vessel, blood will flow through it. In such cases the needle should be removed and a fresh one inserted into a different place. If these precautions are carried out there will be no danger of injecting bismuth into a vein and the risk of sepsis will be reduced to a minimum.

Treatment of Type "B." Treatment is started as in Type "A." Ten injections of 0·45 gm. of "914" are given in bi-weekly doses in conjunction with eight intramuscular injections of bismuth as described above. Frequently after this course the W. R. becomes negative, but relapse is likely unless further treatment is given.

Three months after the commencement of the first course, if the W. R. is negative and remains so, courses at three-monthly intervals should be given, consisting of eight doses of 0·45 gm. of "914" and eight doses of bismuth, as before. If, on the other hand, the W. R. remains positive, every course should consist of ten doses of 0·45 gm. of "914" with eight doses of bismuth. When the W. R. becomes negative and remains so, at least four more courses of eight doses of both "914" and bismuth should be administered. At the end of this period it is advisable to have an examination made of the cerebro-spinal fluid. If this be normal then a blood W. R. should be done every three months for two and a half years. All these tests being negative, cure may be assumed. If, however, at any time the W. R. becomes genuinely positive, treatment will have to start again as for Type "B" cases. It is very rare for a relapse to occur after the W. R. has been negative for two and a half years.

Treatment of Type "C" cases. Provided there are no cardiovascular, meningeal or neurosyphilitic symptoms present, this type of

case can be treated in a similar manner to Type "B," but, in addition, potassium iodide should be administered between the courses. This drug is of great value in assisting the resolution of the gummata which are so frequent a manifestation of syphilis at this stage. If potassium iodide cannot be tolerated by the patient, some other form of iodine may be tried, or some form of mercury be given instead as this drug tends to increase the defences of the body against syphilis. Treatment should be continued until the W. R. becomes negative and remains so. When this occurs, at least one year's further treatment with "914" and bismuth should be given before starting the three-monthly Wassermann reactions for a period of two and half years.

In latent and tertiary syphilis, bismuth is of more value than "914," probably on account of its slow absorption. It is always available in minute quantities when required to assist in the destruction of the syphilitic virus, whereas "914" is only available for a few hours after injection and in that time may not reach the affected part. Before considering a case cured, a complete examination of the cerebro-spinal fluid should always be made.

CARDIO-VASCULAR LESIONS

Treatment of Type "D" cases. The heart and arteries may become infected with syphilis a few months after the onset of the disease, but it is usually from 5–15 years before definite symptoms appear. A minute and careful examination of the patient must be made so as to detect, if possible, the early manifestations of this disability. As soon as cardio-vascular involvement is noted, treatment should begin without any delay. The essentials of such treatment are complete mental and physical rest, cardiac tonics, iodides and intramuscular bismuth in small doses. In the earliest stages of cardiac involvement arsenic may be given in minute doses, but in the presence of aortitis or of cardiac deficiency, arsenic is much too dangerous a drug to administer. This form of treatment should be withheld until proper compensation has been established, and then only be given in small doses.

There can be no routine method of treating syphilitic heart disease. Every case must be treated as a separate entity. The object is slowly and surely to eliminate the spirochætes from the infected areas without doing any damage to the organs involved. Herxheimer's reaction should be avoided at all costs.

Of late, *tryparsamide* has been used with success in cardio-vascular syphilis, but like other forms of arsenic its administration should be delayed until the heart lesion has been fully compensated.

As only small doses of anti-syphilitic drugs are used, a course of treatment should be prolonged for about three months. Such a course as is outlined below for an adult of average weight will prove useful:

Potassium iodide 10–20 grs. t.d.s. with cardiac tonics if necessary, and bismuth in weekly doses, starting with 0·05 gm. and increasing the dose by 0·05 gm. until 0·3 gm. is reached, then continuing with this amount for ten weeks in all. About the fifth week, if the heart condition is satisfactory, minute doses of "914" may be given, starting with 0·05 gm. and increasing by 0·05 gm. until 0·3 gm. is reached. Eight doses should be given. Some authorities prefer to give intramuscular arsenic, such as sulpharsenol, as it is more slowly absorbed. The main point to remember is that, when arsenical preparations are used, careful examination of the patient should be made from time to time so that any contra-indication or complication may be noted early and dealt with accordingly. With arsenical medication it is advisable to keep the patient in bed for some weeks.

After the course just described is complete and if the result be satisfactory, anti-syphilitic treatment is stopped for a period of six weeks to two months. A further course is then given, and, if the heart condition permits, increased doses of bismuth, and later arsenic, may be administered. The W. R. should be examined periodically to note progress. Several courses should be given, gradually increasing the interval between the individual periods of treatment. Even if the W. R. *becomes negative, anti-syphilitic therapy should be continued at yearly* intervals for several years.

MENINGO-VASCULAR SYPHILIS

The same general principles of treatment should be applied to *meningo-vascular syphilis as those used in the cardio-vascular lesions.* Iodides, bismuth, and later arsenic, should be administered, the last two drugs in slightly larger doses than those employed for cardiac involvement. Great care and constant observation are necessary to avoid untoward results. Fairly frequent Wassermann reactions and an occasional examination of the cerebro-spinal fluid will show how progress is being maintained and will be a guide to the future treatment required. Early cases can, as a rule, be cured, but in the later stages of meningo-vascular syphilis, very prolonged medication will be necessary. *Often the best that can be expected is the maintenance of* a continuous latent period.

PARENCHYMATOUS SYPHILIS

The foregoing principles should also be employed in combating syphilitic parenchymatous lesions.

The more modern preparation known as tryparsamide is of considerable value in the treatment of these cases. This is a pentavalent arsenical compound with a high arsenic content. It is well tolerated and seems to have a more specific action in neurosyphilis than the earlier arsenical preparations. It may be given by intramuscular or intravenous injection. Some recommend the oral method of administration, but it is doubtful if the proper therapeutic effect is produced if this route is employed. Tryparsamide is a white powder which is easily soluble in water. The dose is from 1 to 3 gms. If it be given as an intramuscular injection, it should be dissolved in the proportion of 1 gm. to 1 cc. of freshly-distilled water. If it be used intravenously, 1 gm. to 5 cc. of water will be required, the dose in either case being the same. A course for an average-sized adult will consist of ten weekly doses, the first two being of 1 gm. each, the next two of 2 gms. each, and the remaining four of 3 gms. each. A further course may be started a month later, but should be preceded by a course of iodides and bismuth.

Tryparsamide, in spite of its high arsenic content, is very much less toxic than "914" and can be used over long periods without giving rise to untoward effects. It is very much slower in producing serological changes in the blood and cerebro-spinal fluid, but in conjunction with iodides and bismuth a marked improvement in the disease will be noted. Also it has valuable tonic properties and patients will often remark on how well they feel after a few injections of this drug.

The number of courses should be determined by the improvement found on examination of the cerebro-spinal fluid, colloidal gold curve, cell count, W. R., etc. In any case anti-syphilitic treatment must be continued for years.

Contra-indication to Tryparsamide. A pathological condition of the optic nerve is practically the only contra-indication, but unless the condition is severe, the drug may be administered with caution. Examination of the optic fundus should be made from time to time during the course to determine the advisability of withholding the drug.

As pointed out previously, neurosyphilis is not always attended by a positive W. R. of the blood, and therefore occasional examinations of the cerebro-spinal fluid should be made to assess the progress towards cure.

Of late, *malarial infection* has been employed with considerable

success in the treatment of general paralysis and tabo-paresis. Suitable mosquitoes are infected with benign tertian malaria (*plasmodium vivax*) and allowed to bite the patient, or the infection may be conveyed to him by subcutaneous injection of the blood from a malarial subject.

It is now usual to inject the infected blood direct into a vein. About 3 cc. are used. It is unwise to use more than this amount of blood if the donor belongs to a different group from that of the recipient. Blood mixed with a 2·5 per cent solution of sodium citrate in the proportion of 1 to 5 cc. of blood should be used unless the injection be made at once. Sodium citrate of this strength does not affect the vitality of the malarial organism.

When the injection is conveyed from patient to patient without using the mosquito as an intermediate host, the sexual forms of the plasmodium tend to die out. This does not affect the pyrexial syndromes, nor does it lessen the therapeutic value of the attack. Furthermore, it has been stated that this form of malaria is more easily controlled and cured by quinine than the mosquito-borne disease.

When infection takes place, the typical rigor occurs in due course. Eight to twelve of these pyrexial attacks are allowed before antimalarial treatment is instituted. After the requisite number have occurred, quinine is administered until the malarial organism is eradicated from the body. When the patient has fully recovered from infection, a course of bismuth and tryparsamide is administered, as already described. Several other methods have been introduced with the idea of producing pyrexia, such as T.A.B. vaccine, hot baths, infection with relapsing fever, etc., but none of these shows the therapeutic value of malaria infection.

It is doubtful if the pyrexia produced is the direct cause of the improvement in general paralysis and tabo-paresis. The malarial organisms or their toxins seem to have special destructive action on the syphilitic virus in these conditions, whereas in other parts of the body affected with syphilis they have no apparent curative effect. It has been repeatedly demonstrated that considerable improvement and sometimes even apparent cure is accomplished by malarial therapy in many cases of general paralysis, especially if they are treated early.

Meagher, in his report to the Royal Society of Medicine on General Paralysis, has pointed out the value of this form of therapy. He states: "It offers more promise of success than any other form of treatment that has been given extended trial." The number of cases of general paralysis, he quotes, who have been discharged from hospital as markedly improved after malarial infection is very encouraging, i.e.

about 25 per cent of the total admitted. Prior to the use of malaria, the improved cases were only about 3·4 per cent. If cases of general paralysis were treated early there would be, presumably, an increase in the numbers able to return to their ordinary duties.

The combination of malarial and arsenical treatment with the administration of bismuth and iodides has altered the prognosis of neurosyphilis to a very remarkable extent. The expectation of life has been greatly increased and many are able to carry out their daily vocations, who, without such treatment, would be either dead or hopeless imbeciles.

Treatment of Type " E " Cases of Congenital Syphilis. Syphilitic infants, unless marasmic, are, as a rule, well able to tolerate arsenical treatment. Intramuscular injection is to be preferred to intravenous, as the absorption of the drug is slower and there is much less difficulty in administration when the intramuscular route is employed.

The treatment should be combined with bismuth or mercury, or both, the latter being used as an inunction daily in the form of mercurial ointment. Later on, mercury and chalk is a useful preparation especially at the time of teething.

If the child is born with manifest cutaneous lesions it is beneficial to add perchloride of mercury to its bath, about 5 grs. to the gallon of water. Due precautions must be observed by the nurse if she is to escape infection, and every care be taken to protect other members of the community. Careful note should be made of the general health and of any change of weight in the child, as an indication of the success of treatment Serological examinations of the blood are also made from time to time.

An arsenical compound specially prepared for intramuscular injection must be given, such as sulpharsenol or kharsulphan. It is advisable to start with 0·005 gm. in weekly doses, gradually increasing up to 0 02 gm. in about ten weeks' time if the child continues to put on weight and otherwise seems to improve. These minute doses are given to prevent a possible Herxheimer's reaction. In cases of marked marasmus, arsenic should be withheld until a course of mercury and bismuth has been given. Once improvement has become manifest, arsenical therapy should be started.

The dose of bismuth recommended is 0·025 gm. of the metal as an intramuscular injection. When the combined treatment of arsenic and bismuth is given, the injections should not take place on the same day but be spaced with regular intervals. Syr. ferri iodid. is a useful tonic in 5 minim doses t.d.s., and should be given over long periods.

A course of combined therapy consists of eight to twelve doses according to progress. The treatment should be continued for at least one year after the W. R. becomes negative.

As the child grows older, the doses of the various drugs are increased, and Young's formula for estimating dosage is useful.

Treatment of Syphilis in Pregnancy. Every pregnant woman who is suffering from syphilis, irrespective of whether it is latent or not, provided there are no definite contra-indications, should have intensive treatment of the disease; otherwise there is a grave possibility that the child, if it survives the period of gestation, will be born with active manifestations, or show some of the stigmata of congenital syphilis.

The virus is conveyed to the fœtus from the mother about the fifth month of pregnancy. If maternal infection takes place later than this, there is a possibility of the child being born without having contracted the disease, though it is almost certain that it will become infected, either during birth or shortly afterwards by contact with the syphilitic mother.

During pregnancy there is often a remission of symptoms and the W. R. may even become negative. It is important that such an occurrence should not lead to a relaxation of the treatment, which is particularly important at this time for the sake of the child.

If suitable therapy is carried out, the expectation of a healthy child becomes almost a certainty, and the sooner the methods employed to combat syphilis are instituted the more likely will this be so.

As the liver and kidneys have an increased amount of work to perform during pregnancy, there is, in consequence, a greater strain on these organs. Due care must be taken to prevent any complication arising which would contra-indicate the administration of arsenic.

It is recommended that continuous treatment should be carried out during the whole time of gestation. If the infection is fairly recent, "914" should be given in weekly doses of 0·45 gm. for six weeks, followed by eight doses of intramuscular bismuth, 0·2 to 0 3 gm. in combination with iodides, injected at weekly intervals into alternate buttocks. At the end of the second period of six weeks, "914" medication should be carried out, with alternating courses of "914" and bismuth, until the child is born. If there be any involvement of the cardio-vascular or meningo-vascular systems, etc., the treatment recommended previously for these conditions should be employed.

Comments on Treatment. When treating syphilis, accurate records should be kept of such details as the drug used, the amount given, and the dates of administration. The results of Wassermann reactions with

their dates should also be noted, as well as any reaction which may occur during a course of treatment. These records will prove of value when assessing progress or determining cure.

It should be impressed on the patient that treatment must of necessity be carried out for a considerable period of time if a cure is to be effected, and furthermore that a very grave risk is run if treatment ceases when the manifest lesions disappear. Even after a cure is assumed it is advisable to have an occasional W. R. taken in order to ascertain if the cure be permanent.

It is very doubtful if one attack of syphilis confers immunity against subsequent infection, though it frequently happens that a second attack does not conform to the sequence of events usually associated with the disease. For instance, the period of incubation may be much curtailed or take a much longer time to become manifest. The onset of secondary lesions may also be delayed or may even occur about the same time as the primary sore is noted.

Some authorities consider that a certain number of syphilitics when cured of the disease are immune to further attacks, but no absolute proof of this theory has yet been found.

It has been estimated that about 10 to 15 per cent of those who have been cured of syphilis become the subjects of a fresh attack, and even third infections have been recorded. A vast amount of research work is yet necessary before the question of immunity can be decided upon one way or another.

Arsenic-resistant Syphilis is a condition which is fortunately comparatively rare, but its possibility should always be borne in mind. The theory is advanced that there is a certain type of spirochæta pallida which is apparently more or less immune to the destructive effects of arsenic in the doses used in the treatment of syphilis.

I have seen cases belonging to Type " A," i.e. with a primary sore and a negative W. R., in which the spirochæta pallida remained active in the sore during the whole of the first course of arsenic, and on one occasion after the lesion had healed the organisms were still found in the serum obtained from the region of the scar.

In such cases the W. R. always becomes positive and usually secondary manifestations appear. I have also demonstrated live spirochætes by blistering a skin syphilide at the end of a full course of " 914." It has also been noted that a broken-down gumma may fail to react to arsenical therapy and the diagnosis be altered in consequence.

It is a moot point whether these spirochætes are permanently resistant to arsenic, as it has been found, in some cases at any rate,

that this resistance suddenly disappears, so that, if a further course of arsenic be administered, the ordinary therapeutic effect is obtained. Such cases should be given long courses of bismuth injections in combination with iodides and some form of mercury. A course of arsenical treatment is given from time to time on the assumption that the resisting power of the spirochæte is not permanent.

The true explanation of this curious phenomenon is as yet unknown.

PART XXXVI

PHYSICAL MEDICINE

by

SIR ROBERT STANTON WOODS

PHYSICAL MEDICINE

INTRODUCTION

That branch of medical science which has, only comparatively recently, come to be known as "Physical Medicine," includes within its scope forms of treatment whose origins date back longer than those of any other remedial or preventive measures. With the gradual establishment, however, of other therapy upon a more and more scientific basis, so-called physical methods fell under a cloud of disrepute as partaking of quackery. Much of this suspicion can be traced to the lack of exercise of control over the administration of these methods whereby there arose a class of technicians who not only grossly exaggerated their possibilities but seized advantage of this absence of control to undertake the treatment of the sick without medical supervision and therefore without any pretence of adequate diagnosis. To the Incorporated Society of Trained Masseuses, now the Chartered Society of Massage and Medical Gymnastics, started in 1894, can be credited the first successful effort in Great Britain to deal with the situation, not by any legal compulsion but entirely by attaching to its members a status which technicians could not afford to disregard and, at the same time, by establishing the principle that its members were debarred from administering treatment unless instructed to do so by a medical practitioner. This restriction was, however, in one sense purely nominal because the actual prescription of the remedy or remedies devolved of necessity upon the technician in default of any real experience or knowledge on the part of the medical man. It was not until much later that, partly because of this anomaly but largely owing to the increasing complexity and danger of physical methods, their study and practice, together with a study of the disease conditions which especially called for these forms of treatment, were felt to be of sufficient importance and scope to engage the main professional attention of individual practitioners.

The scope of "Physical Medicine" comprises diagnosis and treatment by means of agents and methods other than ingesta or pure surgery. Logically, this definition includes roentgenology and radium therapy; by convention, X-rays and radium are frequently excluded

from the practice of physical medicine and they will not be considered in this section. Finally, this speciality has its preventive aspects in the wide field of health exercises, the study and administration of which are now known as "Physical Education." *With the exception of certain forms of irradiation, the methods of treatment under consideration aim at one or other of two physical principles, namely, the application of heat and the administration of movement.* Under the former can be included hot baths, radiant heat, infra-red irradiation, diathermy and, at any rate in part, short-wave therapy. The direct current, particularly where its application is directed towards deeper structures, depends partly for its effects upon heat production; even the therapeutics of X-rays and radium have recently been credited to molecular heat generation. It does not need to be pointed out that massage and mechanical vibrations aim at moving pliable tissues, and that the main effect of faradism is one of muscle movement; whilst the ultimate effect of all low-tension currents is to cause movements of ions, and ultra-violet radiations depend upon electronic movement. Their physiological influence is even more uniform and this is, almost without exception, attributable to circulatory stimulation. As will be shown, some of the exceptions are only apparently to be excluded from this general statement. Thus, baths of all kinds owe their therapeutic value to their influence upon cutaneous circulation, and it is very doubtful whether their chemical content has any effect beyond this, whilst the like remark applies to all surface administrations of heat. Even heat which is generated in deeper tissues by diathermic currents or by short-wave application has probably no more specific effect, whilst circulatory stimulation is the main if not the only function of massage, movements, mechanical vibrations, and low tension current therapy.

MASSAGE

This therapeutic measure has probably been in use since times that are not historically recorded and is the most extensively used, and one of the most generally misapplied, of all the physical agents. The great majority of surgeons must be familiar with its four main "movements." *Effleurage* is applied with the whole of the palmar surface of the hand and digits which, without any suggestion of grasping, are moved along the skin. The degree of pressure exerted varies, according to the effect which it is desired to produce, from the lightest possible stroking to as firm application as can be borne without pain. In dealing with a limb, the direction of movement is always centripetal and the movement must be rhythmical and slow. Passing over a bone, and especially a

bony prominence, the palm ought to recede from this and the procedure should never elicit tenderness. This last rule should apply to the whole of the administration of massage. Where a complaint of hurt is made, the force used ought to be diminished temporarily; if pain is still elicited, massage should be suspended.

Petrissage or Kneading is directed almost always to the long muscles of the limbs, though naturally the overlying skin and fat also come under its influence. The relaxed calf, for example, is grasped between the palm and thenar pad, carried as it were away from the leg, and with a circular motion replaced and lightly pressed against the bones. No assistance in doing this comes from the thumb or fingers; if this happens, an unpleasant or even painful sensation of pinching arises, whereas petrissage, skilfully applied, can be one of the most pleasant parts of the whole massage "technique." Both hands are frequently used simultaneously.

Tapotement or Hacking is administered with the ulnar borders (or rather, by a circular movement, with the dorsal surfaces) of the last three fingers of both hands which are quickly raised and lowered from loose wrists, the hands acting alternately. This is a highly skilled part of massage technique and ought not to cause any sensation of sting. A modification of this is a similarly applied beating with closed but not clenched fists, a manœuvre which, if skilfully executed, can be applied even pleasantly and yet with considerable force.

The fourth of the massage "movements," *Friction*, is administered by the pads of either the thumbs or the index and middle fingers pressing the skin against the deeper tissues and moving it in circular fashion over these. After a few turns on the same patch of skin, the pads glide lightly to a neighbouring patch where the manœuvre is repeated before again passing on. In exerting the pressure, which varies in force as requirements demand, the pads of the fingers do not glide along the skin but move it on the deeper structures. An analogous technique makes use of the "heel" of the hand when one wishes to apply frictions to massive muscles such as the erector spinæ.

As already pointed out, the *physiological influence* of massage falls mainly upon the circulation. It is easy to understand that effleurage should act mechanically upon superficial valved vessels, whilst it cannot be doubted that the rhythmic application of pressure upon the muscles brought about by kneading acts similarly upon the centripetal vessels of these. Effleurage and kneading act in this way both in conditions, traumatic or otherwise, of recent origin and in the more established or chronic states, whereas the circulatory effect of frictions is best

employed in old-standing infiltrations which are perhaps on the way towards organisation. Hacking undoubtedly also promotes vascular flow but rather by causing a dilatation of superficial arterioles and capillaries, although, as will be mentioned later, the whole of massage also acts in this manner. Pemberton and Osgood point out that especially in acute disease conditions, where venous and lymph flow are embarrassed, there is danger of over-taxing already over-taxed and perhaps injured vessels, and that massage, although of the greatest assistance in many such states, must be carefully and even tentatively applied. Finally, there is said to be evidence to indicate that amongst the physiological effects of massage is some influence upon general carbohydrate metabolism. This statement must be looked upon with suspicion because of its being a suggestion that might arise on *a priori* grounds, owing to the known effect of massage upon muscle nutrition.

In applying effleurage, light or almost negligible pressure is analgesic, and Lucas Championière, in advocating the immediate application of effleurage to severe sprains and other such injuries, advised that the first few movements of the hand should not even touch the skin but that the hand should be very gradually approached to it. This manœuvre will allay the natural fear on the part of the patient of any manual interference with what is probably an acutely painful and swollen region, and was given the accurately descriptive name of *glukokinesis*. So soothing can it be that even the muscular spasm in association with a Colles' fracture tends to disappear and, in the case of a sprained and swollen ankle, if the pressure is very gradually increased a joint which at first resents the lightest touch will, after some minutes, tolerate as deep effleurage as it is advisable to administer at this stage. This local sedative effect is, of course, partly, even if not entirely, due to reduction of swelling. Whether the general sedative or hypnotic effect of massage can always be attributed to circulatory influence is doubtful. It is probable that when general massage induces sleep this effect is largely due to an influence on the general circulation in so far as this comes under its control. There is, however, a special dorsal trunk technique for insomnia whose effect is undoubted and which cannot always be explained upon grounds of suggestion. It may be due to the multiple afferent cutaneous stimuli, rhythmically and uniformly applied, acting in a manner analogous with certain other special sensory stimuli which have a well-known hypnotic influence.

The clinical effects then of massage, both general and local, are demonstrable, but these do not admit of explanation by means of examination of the urine or by investigation of the basal metabolism.

No effect of massage upon these can be demonstrated. Nor are the reputed effects of general massage upon the blood established. It is said to increase the oxygen capacity, the hæmoglobin content, and the red cell count. Almost certainly, if these changes do result, they are due to a stage in convalescence accompanying, and in some cases probably due to, the administration of general massage and are in no sense a specific effect of this treatment. Locally, on the other hand. gentle effleurage does give rise to a transient increase in the width and visible complexity of capillaries, whilst with more forcible treatment this effect is more prolonged. In this manner also, in addition to mere mechanical action on the venous and lymph flow, local metabolism is influenced; and as one-fourth of the circulating blood at any one moment occupies the capillaries and arterioles, the possible extent of the influence of massage is obvious.

Clinical Indications for Massage.

(1) Perhaps the widest field is concerned with the *Removal of Exudate.* In acute conditions, this applies almost exclusively to injuries. In recent trauma, it is perhaps advisable always to begin by excluding contra-indications, and the most obvious of these is the danger of displacing bony fragments where a fracture is present. Apart from this risk there must be few fractures where massage will do harm if skilfully administered and, wherever the method of immobilisation permits of its use, it ought always to form part of the treatment from the earliest days. Especially is this true in the case of a fracture which either involves a joint surface or is so close to a joint that the latter is implicated in the exudate. There is no doubt that the greater the amount of hæmorrhage and exudate and the longer these persist, the greater is the liability to subsequent stiffness from organised adhesions; there is equal lack of doubt that massage, early administered, has the effect of helping to remove the early exudate. There is much less urgent need of massage where a joint is not involved, but even here the exudate can be directly responsible for considerable atrophy and loss of function of muscle. The present vogue, whereby nearly every fracture of a limb involves encasing the limb in fixed plaster-of-Paris for many weeks, does not, of course, permit of massage until any exudate that persists is advanced towards organisation; and, in the absence of very expert application combined with almost continuous supervision, the results to function of such treatment are not infrequently disastrous. Accurate co-aptation, efficiently maintained, is one of the first essentials in the treatment of fractures, but anatomical perfection of bone is by itself of minor importance as compared with

restoration of function. Where no fracture exists and a joint is the subject of severe trauma followed by great swelling there is no objection to massage from the earliest moment, whilst no other remedial measure will so rapidly and effectively get rid of the pain and swelling. There is one set of circumstances which is said to constitute a contra-indication, namely, a dislocation of the elbow at or about puberty, owing to the supposedly increased risk of formation of new bone in front of the joint. Massage alone cannot be said to act thus, however much the risk can be increased by too early movement which, in these circumstances, ought not to be permitted during the first four weeks. In joint trauma the risk of increasing hæmorrhage cannot be great and at any rate does not, in all probability, extend beyond the first two days. For such conditions as the above only effleurage can be undertaken. Should the method of immobilisation preclude access to the actual site, massage, given proximal to this, will help.

A not uncommon sequela of inefficiently treated injuries, and especially of fractures, is an infiltration, varying in extent and density, of the soft structures in the neighbourhood of the part affected. Massage, combined with electrical stimulation of muscles and preceded by heat, is urgently called for in this condition. All the four main movements of massage should be employed, the most effective of which is friction in depth. A similar treatment is also applicable to infiltration following septic infection of limbs after infective activity has passed.

(2) The second group of disease conditions calling for massage is *Atrophy of Muscle*. The ætiology of this group is so wide that its members cannot be specifically mentioned. That in which most good results is atrophy arising from joint affection. On both theoretical and observational grounds it is true to say that massage does at least improve muscle tone, if not its bulk, partly by promoting circulatory activity but also because tapotement excites activity of the muscle bundles. Again, although there are records of experiments on rabbits which would indicate that a paralysed muscle, whose peripheral motor neurones have been divided, does not increase in bulk as the result of massage, yet this treatment can hardly fail to act on the circulation and therefore advantageously upon the muscle metabolism, because it must be borne in mind that absence of muscle contraction removes one important circulatory excitant. On the other hand, paralysis of upper neurone origin benefits, as one might expect, hardly at all from massage.

In all these disease states, either traumatic or due to other causes, the fact previously emphasised must not be forgotten, namely, that the tissue cells function abnormally and that their functional load must not

be increased beyond their capacity. It is therefore wise at the beginning of a course of such treatment to err on the cautious side.

(3) In a group by itself especially susceptible to improvement by massage is *Fibrositis*. Although this is a widely comprehensive disease group, hardly any of its members offer contra-indications, but sensory perineuritis is a very definite exception to this generalisation ; indeed, almost a diagnostic factor in the acute stage of this condition is its adverse reaction to massage. Perhaps the very common fibro-myositis may be considered as affording the best example of a favourable response to massage of all this group, but even here its administration must be carefully supervised as perineuritis is a not infrequent complication. A further feature of its response is that this is, as a rule, greatly assisted if preceded by radiant or other form of heat. Generally speaking, massage, although it cannot be said to replace normal function, is called for in many conditions in which exercise is either impossible or not permitted. In this perhaps lies its main function when given as part of the treatment in the next disease group.

(4) In *Rheumatoid Arthritis* and even in *Osteo-arthritis* it is doubtful whether massage, applied directly to joints, is ever helpful. As treatment for the accompanying muscular atrophy, however, it is of undoubted benefit. Especially is it almost an essential part of the treatment in the former disease, not only for the affected limbs but perhaps even more imperatively as a form of general treatment in view of the characteristic anæmia, faulty metabolism, and general debility which always constitute part of this disease syndrome. In arthritis and fibrositis there exists, as pointed out by Pemberton and Osgood, a vicious circle. The pain inhibits movement and in consequence there is a slowing of the circulation with a depression in metabolic rate, which in turn tends to advance of the disease state. " There are therefore few sufferers from these diseases in which general and local massage is not indicated," although, as has already been stated, massage is of doubtful utility if applied directly to joints in either rheumatoid arthritis or osteo-arthritis. In the treatment of certain other forms of joint infection it takes a very important place.

(5) Notably is this so where, as a consequence of *Coccal Infection* of joints, there remains a more or less dense infiltration of the capsule and peri-articular tissues which, if allowed to persist, will result in permanent limitation of movement. As soon as all infective activity has ceased, massage, and especially frictions, again in combination with some form of superficially applied or deeply generated heat, is almost the only treatment, apart from actual functional use (so often impossible),

which will have any effect in removing or limiting this rapidly organising exudate. There is one disease complication which constitutes an exception to the rule against the use of massage during acute infections of joints. Even in the painful stage of acute gonococcal arthritis skilled massage often appears to limit the course of the arthritis and to render stiffness a less likely sequel. Naturally at this stage only the very lightest effleurage is tolerable, but this appears to have an unexpected sedative effect even in one of the most painful and tender of disease conditions. For the later stages of an acute infective (coccal) arthritis, after evidence of activity has disappeared and where the extrinsic joint tissues are infiltrated, massage is not only invaluable but essential. The whole of the technical range ought to be used, but frictional massage is especially effective, and the treatment ought always to be preceded by application of one or more of the other physical agents which act upon local circulation—heat, infra-red irradiation, diathermy, etc. Part of this infiltration affects peritendinous tissues, and rhythmic stimulation of muscle contraction by faradism therefore plays a useful part. Finally, assisted active movements obviously constitute the most natural means of restoration of function and ought never to be omitted. The most common error which is made in the exhibition of physical treatment, and more particularly in conditions such as these, is impatience and a lack of persistence. A moment's consideration will bring conviction that an extensive exudate, and *a fortiori* one which is partly organised towards the formation of fibrous tissue, will not rapidly disappear. And yet this is obviously expected by the medical man who orders a masseuse to give six applications of massage to a joint which is the subject of dense infiltration as a sequel to coccal infection. On the other hand, persistence will very often result in a totally unexpected degree of functional recovery. The prognosis, of course, is very much worse where radiographic osseous and cartilaginous changes are present.

General massage is a therapeutic measure too seldom prescribed, and especially perhaps after severe operations. Theoretical grounds have already been discussed for the view that massage affects local metabolism whilst there is abundant clinical evidence of the effect. It would therefore be logical to expect a general metabolic improvement from its application to an extensive part of the body and there can be very little doubt that such effect does occur. There is, as previously mentioned, a slightly specialised technique of spinal massage which does sometimes act as an hypnotic after an exhausting surgical operation.

Few, if any, contra-indications to general massage exist; there is, however, a small percentage of individuals who resent it and in the case of these it is likely to do more harm than good, especially as part of its function is to produce a sedative effect.

HEAT

It has been pointed out that the administration of massage consists in producing movement of and in certain structures, and a consideration of the active and passive movement of joints would perhaps follow logically upon the section dealing with massage. As heat and massage, however, are very often complementary in practice, it will be more convenient to associate them closely in discussion. Heat can be either applied to the body from an external source or generated in the tissues themselves. *Means of applying heat are numerous and it is extremely doubtful whether the various forms of its application show any essential therapeutic differences from one another.* Practically, it appears to be a matter of indifference whether the external source is one which also emits light rays or consists of a series of wires raised to a high temperature by the passage of an electric current. Specific therapeutic effects have recently been claimed for infra-red radiations; the pyretic bath (see page 5346) would appear to perform a slightly specialised function, and certain chemical substances are introduced into some of the forms of heat application. Heat from an external source probably does not penetrate to any appreciable depth, though actual measurements of this are unreliable; nevertheless, the deep effects of surface heat are indubitable. As already mentioned, diathermic currents and short-wave therapy can give rise to the generation of heat in the deeply-seated tissues themselves.

The *physiological effects* of a general application of heat are largely circulatory. There occur an undoubted rise in the general metabolic rate and an increase in the respiratory rate with an increased output of CO_2; exudation of sweat is increased, with again a rise in excretion of CO_2; and the urinary acids are in excess of normal, once more with increased excretion of CO_2. Pemberton and Osgood point out that this leads to an acid-alkali imbalance with excess of alkalinity; and it is remarkable that after a time general heat baths are attended by an increasing alkalinity of the sweat. It is obvious that no lead on chemical grounds is obtained from these observations. Heating of a part of the body gives rise to increased blood supply to this area of skin and probably to a corresponding deep vascular activity. One result of this is relief of pain especially noticeable in conditions, such as

fibrositis and chronic arthritis, which are associated with inactive circulation. Because of its stimulating effect on deep circulation it forms a good preparation for local massage in conditions where, owing to past inflammation or injury, the tissues are infiltrated with an exudate of greater or less density and in a more or less advanced stage towards organisation. Heat is said to "soften" such tissues in preparation for massage The probable explanation of this observed fact is that many small vessels have been occluded whilst others are probably imperfectly responsive to sympathetic control, and the cutaneous vasodilatation resulting from heat application leads to reaction on the part of deeper vessels, thus ensuring a better exchange with more adequate removal of exudate products and an improved local metabolism generally. No arbitrary limits can be set either to the degree of temperature applied or to the length of exposure. This depends mainly upon individual factors. The temperature ought never to become uncomfortably high, and repeated warnings in this respect are necessary as many patients are under the misapprehension that the higher the temperature the greater the benefit obtained—an impression which is not infrequently responsible for very persistent burns. An average length of exposure to dry heat is twenty minutes, but a shorter exposure is advisable if the skin perspires easily. Most unpleasant happenings have resulted from failure to detect a loss or diminution of cutaneous appreciation of temperature change.

A special method of applying moist heat is by means of the so-called "pyretic" bath in which the whole body, with the exception of the head, is exposed to steam at a temperature of about 110° F. for fifteen to twenty minutes, this being followed, as soon as sweating on the forehead is definitely established, by a warm water bath, preferably one through which air is pumped under pressure.

The *clinical indications* for heat therapy are wide and can only be discussed in general terms. Its local application might be expected to benefit conditions where *defective circulation* plays a part and, until the recent introduction of other forms of physical treatment, radiated heat was a recognised form of treatment in thrombo-angeitis obliterans and Raynaud's disease; it enters extensively into the treatment of fibrositis where the circulation is notoriously apt to be defective; and it is of great service in the local treatment of arthritis, another disease state associated with poor blood supply. More particularly is its use indicated in conditions of defective circulation associated with pain. This again is exemplified by fibrositis in which the outstanding symptom is pain. Widely different interpretations are put upon this term

"fibrositis." Some would limit its use to localised fibrous and muscular "rheumatism"; others speak of generalised fibrositis and panniculitis, and there is no doubt that a condition of generalised sub-acute "rheumatism" does occur, apart from arthritis; whilst others again would include most of the metabolic and infective disease conditions affecting any part of the mesoblastic tissues, with arthritis in all its forms. Whatever conception of its inclusiveness we entertain, most of its forms call for heat. Thus, heat is an essential part of the treatment of the common fibro-myositis of the trapezius, though its application has to be very carefully controlled in what is probably a complication of this, namely, brachial perineuritis; we cannot dispense with its use in the analogous affection of the lumbar muscles and fibrous tissues, whilst the analogous complication, sciatica, reacts much more favourably than does brachial neuritis; and in conditions of peri-articular fibrositis, such, for example, as sub-acromial bursitis, heat is perhaps *the most important of the local applications.*

The rationale of the use of radiant heat as a *preparation for massage* has already been explained. It renders massage much more effective in treating the thick board-like infiltration of soft tissues which is so frequent a consequence of the prolonged immobilisation of fractures, *especially in those which have suffered circulatory interference from* injudiciously applied extension. The striking results of persistence in physical treatment, where a short course may be ineffective, are often seen in the condition just mentioned, if the infiltration affects movements of larger joints. The small joints of fingers and toes are much more resistant, and *injudicious immobilisation and extension* treatment, for example, of a fracture of the surgical neck, are apt to result in a stiffness of the fingers which will resist any or all forms of after-treatment, thus rendering the limb functionless in spite of an ultimately useful range of movement at the elbow and shoulder. The risk of permanent stiffness of the fingers as a result of the above set of conditions cannot be too often or too forcibly stressed. Preceding massage for the late results of acute septic arthritis, heat undoubtedly adds to the effectiveness of the former, and in localised fibrositis this rule also applies. *A joint which has been sprained and not been subjected to early massage is liable to prolonged and troublesome stiffness from either semi-organised infiltration or muscular spasm.* Both these conditions will probably respond better to a combination of heat and massage than to any other form of treatment; the pain associated with eversion spasm at the ankle, for instance, will often react almost immediately to heat. A very effective method of employing this combination is to administer

the massage to the affected limb whilst this rests in a bath of warm, soapy water, the soap rendering the massage easier, more pleasant, and therefore more productive of results.

Administration of heat to the body *generally* is, of course, a means of inducing general sweating. In a surgical treatise, a discussion on such indications as nephritis would be inappropriate. A periodic radiant heat bath is an essential part of the physical treatment of generalised chronic arthritis, though it is difficult to account for this on theoretical considerations. General heat application helps, when not too frequently repeated, in local but moderately extensive fibrositis, as, for example, in lumbar fibrositis, especially with a complicating sciatica, and in the common fibrositis around the shoulder girdle.

The main contra-indication to extensive thermal treatment is a debilitated general state of health, though instances of fainting during its administration are probably attributable to vasomotor disturbance. In any form of physical therapy which may cause a skin burn, such as heat, one must bear in mind those general and local disease states in which gangrene is apt to supervene upon a lesion of the skin.

There are, finally, certain individuals whose make-up includes a dislike of high temperatures in their surroundings and by these even local heat cannot be tolerated.

For the induction of *general pyrexia* much more efficient physical agents are available than any source of externally applied heat.

INFRA-RED IRRADIATION

A specialised form of local thermo-therapy is the so-called "*infra-red*" irradiation. Some reference is made to the electro-magnetic range of radiations in discussing actinology (see page 5362), and the term "infra-red" would strictly apply to all radiations whose wave-lengths are longer than those of the visible octave which give rise to the optical sensation of red. In medicine it connotes those radiations whose wave-lengths are *immediately* longer than these. There are few exceptions to the statement that energy radiations penetrate animal tissue to depths which increase with increase in wave-length of the radiations. The shortest infra-red wave-lengths are of the order of $0{\cdot}75\mu$ ($\mu = \frac{1}{1000}$ millimetre) and these radiations penetrate to an appreciable depth of skin though no satisfactory measurement of this depth is available. On "absorption," the energy is transformed, and in the case of "medical" infra-red emanations this conversion is into heat energy. This band of the electro-magnetic range extends from the red end of the visible spectrum with wave-length of about $0{\cdot}75\mu$ to radiations whose wave-lengths measure about 6μ, beyond this, and until wave-lengths of 1 to 3 metres are reached, lies an unexplored region. From the visible range until the wave-length has increased to 3μ the penetrating power of infra-red energy falls, contrary to what almost universally obtains; beyond this, penetration again rises. Unsupported statements with regard to the depth of penetration of these rays vary in estimate, even to

0·5 cm. or more. Technical difficulties in estimation render accuracy in this impossible and it is probable that this last figure is a great exaggeration where living tissue is concerned. Some doubt is also expressed as to the exact nature of the physical conversion that takes place when these rays reach their limit of penetration and undergo absorption. One form of this is certainly into heat energy, so that infra-red irradiation gives rise to the development of heat at different, but probably very superficial, levels. There is no proof that infra-red radiations, when they encounter living animal tissues, have any physical effect other than this. Nor is there any essential difference between the radiations which produce the sensation of heat and which come from luminous sources and those emitted by dark bodies; both are infra-red. Different sources, of course, vary in intensity of output and there is some difference in infra-red wave-length from one therapeutic lamp to another. Clinically, non-luminous sources of "heat" rays are very valuable for local application, just as are sources which emit "visible" rays in addition. Commercial therapeutic apparatus varies in efficiency, the difference being due partly to wave-length but largely to intensity.

All the statements already made with regard to local heat therapy apply to the use of infra-red irradiation. There are other thermo-therapy methods but these will be discussed under the sections which deal with low and high tension electrical currents and short-wave treatment.

MOVEMENTS

Much of physical medicine concerns the function of injured and diseased joints and of the structures which control their movements. If any function is in abeyance for a prolonged period the organs and tissues which are concerned in the function undergo varying changes, all of which are either primarily or secondarily degenerative in character. Difference of opinion frequently arises as to whether an originally healthy joint may become the subject of "adhesions," merely by being placed at complete functional rest over an indefinite period. The correct view would depend upon the interpretation of the term "adhesions." There is no doubt, for example, that a major joint, otherwise healthy, but which has been immobilised for a long time by hysterical spasm, may be immovable even under general anæsthesia. The "adhesions" in this case would be represented by degenerative changes, mainly in the muscles and in the joint capsule, but probably also in the synovial membrane, tendon sheaths and bursæ. Joint movements have also a profound effect upon the metabolism of the joint tissues and of the muscles. It is obvious therefore that, where a joint is involved in disease or injury, as extensive a range of joint movement as is safe should be maintained during the whole course of the affection. The qualification inherent in this general statement refers mainly to any adverse effect which movement, at any given stage of the complaint, might produce.

It will not be possible to discuss joint movements other than in a general manner. In view of what has just been stated, the first consideration ought to be as to whether passive or assisted movement is likely to be harmful. In order to answer this in any individual instance it will be necessary to visualise the pathological changes which have or may have occurred in and around the joint; but it can be accepted as an almost universal rule that movements which cause *pain* ought to be avoided. If pain arises there is almost certain to be both intentional and reflex muscular contraction opposing the movement, a situation fraught with danger, at least to the muscles. Further, the very existence of the pain on movement is frequently a signal provided by Nature to contra-indicate the movement. It is a rare occurrence, though one that does occasionally arise, that a sudden snap, with muscles relaxed, will tear a soft joint adhesion, the tear being accompanied by severe pain. Another contra-indication, and one which must be continually kept in mind, is any evidence of *increase of the pathological condition* during the few days succeeding any attempt at movement. Should there be an exacerbation of pain, an unusual rise in general temperature or an increase in swelling or heat of the joint itself, any of these ought to be assumed to be evidence that movement must be at least temporarily suspended. An exception to this general statement is that a successful joint manipulation under local or general anæsthesia may be followed next day by a slight effusion which, in these circumstances, does not necessarily call for immobilisation.

It has long been thought that any *bacterial infection* of joint structures automatically imposes complete immobilisation of the joint so long as any evidence whatever of bacterial activity persists. So deeply ingrained is this teaching that a discussion of its soundness is apt to be purely academic, but prolonged observation of sub-acutely and even acutely infected joints would lead one to doubt at any rate the universality of its application. Movements, tentative at first, of gonococcal joints at the earliest moment at which the movement does not increase the pain would not appear to be harmful, and carefully performed movement of joints which are the subject of early rheumatoid arthritis, even in an acute phase, can be undertaken with advantage if exacerbation of symptoms and signs is absent some hours or a day later. Such procedure ought to be undertaken very carefully, if at all, and the risk of damage will probably be lessened if at the same time traction is exercised in the long axis of the limb. In the case of interphalangeal joints, side-to-side and rotatory movements are a wise preliminary and will almost certainly be more tolerable than move-

ments of flexion and extension, probably because, owing to peculiarities in conformation of these joints, the former produce less stretching of sensitive ligamentous structures than the latter. Joints which are less acutely inflamed and which have, through neglect, become fixed at an angle *which wholly or partially precludes function*, may receive great benefit from continuously applied force. Such a condition arises in the course of true rheumatoid arthritis where one or both knees have become gradually more and more bent. In these circumstances the simple procedure of suspending the limb in such fashion that its weight tends to produce extension will sometimes cause considerable rectification where no persistence of treatment by massage, heat, etc., would have the least effect, though, combined with and following upon the extension, these measures help considerably. This extension method is of little avail, as well as being inadvisable, if there is danger of pathological dislocation of the tibia. With still lower activity of local disease and a lesser degree of deformity, plaster-of-Paris with wedges at the backs of the knees will permit of walking whilst the gradual reduction of deformity is proceeding. The plaster may be renewed at intervals under general anæsthesia which will obviate any muscular resistance. There are many devices for persistently applied force directed to overcoming fixed deformities of joints. Most of these, if they promise success, are preferable to and safer than the intermittent passive movements attempted once or twice a day. They are all assisted by a daily application of other physical agents such as massage to the muscles and, if possible, heat to the joints themselves.

One of the main and most obvious contra-indications to joint movements is the danger of *displacing the bony fragments* in the case of fracture. At the end of the last century the prolonged immobilisation, generally in plaster-of-Paris, of fractures of long bones, with simultaneous fixation of the joints immediately proximal and distal to the fracture, was almost universal. This was gradually modified to allow of early mobilisation, especially where a joint was either affected by the trauma or actually included in the line of the fracture. During the past few years, very prolonged and complete immobilisation has again become a vogue and whilst, in the hands of those who are daily handling fractures, the end-results are good, as carried out by those with limited fracture experience, who constitute the great majority, the permanent effects on function can be disastrous. It is still necessary therefore to consider the question of therapeutic joint movements in the case of fractures. The most important consideration is whether movement of a joint will cause displacement of the fragments. If there is

doubt regarding this, movement ought to be avoided. If such danger does not arise it is difficult to see what harm can result from even early joint movement and, on the other hand, much benefit undoubtedly does accrue. Exactly the same argument applies to effleurage: and, as soon as active contractions of muscles are safe, again quite early as a rule, these also, if very slight in extent, can do nothing but good. The aim must be restoration of function, and naturally the first essential to this is as complete anatomical restoration as possible. This having been attained and its maintenance ensured, measures which undoubtedly tend to minimise the risk of other sources of functional defect are called for. To prevent displacement of fragments, immobilisation is necessary, but not for the very prolonged periods which have recently become customary.

The late results of trauma to and disease of joints call, as a rule, for more drastic measures of movement. Again, pain is to be avoided; painful manipulations are very seldom efficacious. After heat and massage, however, a greater range can often be attained by patient stretching than was possible immediately before the treatment, and this is a procedure which ought always to be followed and which will almost invariably result in either complete recovery of range or at least in great improvement, heat being especially useful in the relief of pain.

One of the most difficult matters of diagnosis is to distinguish between stiffness due to pain and that which is caused by organic change such as adhesions; it is also one of the first importance, the treatment being entirely different in the two conditions—the former is much more likely to be overcome by heat and rest, whereas the latter calls for mobilisation. Occasionally, resort must be had to movement during anæsthesia—either local or general, or a combination of both. No fixed rules can be made as to the necessity for this and it is often a *legitimate procedure even if undertaken* tentatively. It is much more likely to succeed in large than in smaller joints; in single joints such as the shoulder than in the complicated wrist joint; after an injury uncomplicated by fracture than in stiffness following either a fracture or resulting from infection, where the joint capsule is probably thickened; and after a course of massage and radiant heat than in a joint unprepared by these measures. As an example of a most hopeful set of circumstances for manipulation under anæsthetic one would cite a shoulder which has been injured a few months previously, in which there has been no fracture, and where treatment by heat and massage has failed to bring about full recovery of range. On the other hand, this treatment even of stiff finger joints will at times result in much

increased ease in spite of the absence of any obvious increase in range. It is now generally recognised that, in order to secure the recovery of joint function, active (voluntary) movements are far superior to passive; they are also probably safer, being inhibited by pain which is often a danger signal. This applies with special force to purposeful movements, and most fruitful of all is actual use of the affected limb at the ordinary occupation of the individual, if this occupation entails extensive range of movement of the joint. Into the actual technique of joint manipulation, with or without anæsthesia, it would here be impossible to enter.

MEDICAL ELECTROLOGY

A very short résumé of a few relevant facts in physics and biophysics will be necessary to the understanding of the place in medicine occupied by electrical currents and radiations.

The electronic view of atomic structure is of an association of positive and negative charges of electricity—protons and electrons. There is a nucleus composed of protons, or of protons and electrons, with "orbital" electrons moving in orbits at varying, but for individual electrons at fixed, distances from the nucleus. (This conception of atomic structure is being almost daily modified.) The term "ion" is given to an electrically unsatisfied particle or atom which has lost one or more electronic charges. Certain compounds (electrolytes) which, in the absence of water, are electrically neutral (the component ions having electrically satisfied or neutralised each other), in the presence of water exist partly in ionic form. To this phenomenon is given the name *ionisation*. Thus, sodium chloride in presence of water exists partly as the neutral compound but partly as temporarily unsaturated ions of sodium and chlorine, individual ions constantly dissociating and recombining. The "passage" of a current of electricity through a solution of an electrolyte leads to a determination of negatively charged ions towards the positive electrode, and vice versa.

Tissue electrolytes such as sodium chloride behave similarly, existing both in an ionised and in an un-ionised state, and are similarly affected by electrical currents. This phenomenon forms the basis of all the effects of low tension currents upon animal tissue. A modification of this is the introduction of extrinsic ions into tissues where an external electrolyte in solution is in contact with part of the body and forms, with this, part of the same electric circuit. A movement of ions in both directions takes place across the area of contact so long as the current is in existence. Introduction of extrinsic ions into tissues—*ionic medication*—now forms only a small part of therapy. It is probable that this takes place, to any therapeutic degree, only at surfaces uncovered by skin, such as mucous membranes, and only to a depth of a few millimetres. An example is the introduction of zinc ions into the wall of an infected sinus, into the nasal mucosa, etc. Almost all the biophysical phenomena associated with low tension currents are due to movements of tissue ions—ionic displacement—consisting of a steady or sudden trend of differently charged ions in opposite directions. As very little is known about the explanation of the resulting physiological effects, the greater part of the therapy of unvarying direct currents is empirical

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Suggestions of ionic bombardment are not helpful. That a steady direct ("constant," "galvanic") current has remedial effects is undoubted and, in conjunction with other physical agents, it is sometimes useful in the treatment of localised fibrositis, painful brachial neuritis (in small doses), traumatic effusion of a joint, etc. It is probable that part of this therapeutic effect is due to a skin stimulation and acts by counter-irritation.

MUSCLE STIMULATION

Where the current strength is not unvarying, another physiological phenomenon occurs, namely, stimulation of muscular contraction. This, however, is also ultimately due to ionic displacement. Whenever a direct (constant) current is originated, having either healthy motor neurones or healthy muscle as part of its circuit, a contraction of muscle-fibres is aroused, followed at once by a relaxation, provided that the ultimate intensity of the current is adequate and that the rise of current to this intensity is sufficiently rapid. During the maintenance of the current at constant intensity the muscle tissue is in relaxation, but another contraction occurs if the circuit is either broken or falls considerably in strength and with sufficient rapidity. This phenomenon again is due to the accumulation of certain tissue ions acting as a stimulus to nerve and muscle function. The contraction process in these circumstances is a momentary phenomenon ("brisk contraction"), and the subsidence of the contraction is almost equally rapid ("brisk relaxation"). Repeated makes and breaks cause repeated contractions and relaxations, until these follow one another so rapidly that first partial and finally complete fusion occurs, producing a prolonged contraction or "tetanus." This occurs when the stimuli succeed one another as rapidly as 30 per second. Reversals of current ("alternating currents") act similarly to makes and breaks. These two phenomena, i.e. brisk contraction and relaxation in response to make or break of a constant current, and tetanus in response to very rapidly made and broken or alternating current, constitute the essentials of normal electrical responses.

REACTION OF DEGENERATION

Where "voluntary" muscle is not supplied by functioning motor neurones, as after division and degeneration of these, the muscle will still respond by contracting when stimulated directly by a make or a break of a direct current. In this case, however, the contraction is appreciably prolonged whilst the relaxation is visibly even more prolonged—slow and prolonged contraction and relaxation. It is not infrequently obvious that the muscle-fibres do not contract simultaneously (worm-like response). If to such a muscle is applied a stimulus consisting of rapidly made and broken or alternating current, of the order of rapidity of a faradic current, no contraction occurs. Finally, if a single wave of such rapidly alternating stimulus (a single shock induction) be applied to the muscle, this also will be ineffective. To such a syndrome, namely, absence of response to faradic stimulation with sluggish and worm-like contraction on stimulating with make or break of a direct current, is given the name "reaction of degeneration." In its full development it is found only in association with degeneration of peripheral motor neurones, and any form of stimulus applied directly to the motor nerve is also ineffective. On the other hand, a muscle, together with the peripheral part of its divided nerve, retains normal reactions for several days after

the division has occurred, and only after from ten to fourteen days is the full reaction of degeneration established, *in other words, after sufficiently profound* degeneration of the neurones has taken place. (It is moreover certain that some change in the muscle-fibre itself is necessary because a curarised muscle will contract if stimulated by the faradic current.)

The explanation of these phenomena is that degenerated muscle fibre can be *electrically stimulated by makes and breaks (or reversals) only* where the current changes are comparatively slow (for example, make and break of direct current) whilst healthy nerve fibre can be excited to activity, not only by such stimuli but also by stimuli whose current change is as rapid as those in a faradic coil. Normally a muscle is stimulated through its motor nerve whether the electrical stimulus is applied to the nerve at some distance from the muscle or directly to the latter, whereas, with degenerated and therefore non-functioning peripheral nerve, the muscle-fibre must be stimulated directly. This explains also the slow nature of *the direct current response where there is degenerated nerve,* because whereas with nerve excitation the stimulus is conveyed simultaneously to all the muscle-fibres, causing a simultaneous contraction of these, in the degenerated condition the separate muscle-fibres do not receive the stimulus simultaneously and therefore contract at different times. This results in a much more sustained contraction of the whole muscle. *Finally,* the above biophysical deduction accounts for a phenomenon which is part of the reaction of degeneration and is known as "longitudinal response. In healthy muscle there is a point of greatest stimulability, the motor point; with degeneration of the nerve, the contraction with minimal current response. In healthy muscle there is a point of greatest stimulability, the motor point; with degeneration of the nerve, the contraction with minimal current strength is obtained when the whole length of the muscle is included in the path of the current, thus ensuring a direct stimulation of the greatest number of muscle-fibres.

There still remains to be explained this difference in behaviour towards electrical stimulation on the part of muscle fibre and nerve fibre respectively. Curves illustrative of this difference can be plotted for muscle with healthy nerve ("nerve" curve), for muscle with degenerated nerve ("muscle" curve), and for muscle with *partially recovered* nerve. The one fact of clinical interest which appears is that, whereas the two former curves are of totally different character, the last, instead of being a modification of both of these, shows two distinct curves —viz. that of degeneration and that of normality. Thus, even the most advanced electrical examination elicits evidence, not of gradual stages of recovery of a single tissue *(nerve), but of two stimulable tissues, muscle and recovered nerve*—i.e. of complete degeneration and of complete recovery

The outstanding difference between these two types of stimuli is the *duration* in time of the current at maximum intensity The duration of the direct current, as this is ordinarily made and broken, is of the order of a large fraction of a second, perhaps $\frac{1}{6}$ to $\frac{1}{4}$, whereas that of a single element of, say, a faradic current is of the order of $\frac{1}{100}$ of a second or less. Actually, the electrical stimulability of nerve or muscle fibre is a function of both intensity of stimulus and *duration in time of the* current, and the term "*chronaxie*" is used to express this characteristic of these two issues.

Clinically, electrical diagnosis is of great value but has its limitations. As

already stated, it applies solely to conditions of organic lower motor neurone affection. It has no relevance to affections of any other part of the nervous system nor is it, except in a negative sense, of help in myopathies; although a reaction has been described which is said to be diagnostic of myasthenia gravis, the existence of this reaction is very doubtful.

The reaction of degeneration, as already described, refers to muscle which is entirely unsupplied with functioning motor nerve fibres. It gives full information merely of the severity of the physiological disturbance. Thus, with wounds, complete reaction of degeneration does not necessarily indicate anatomical, but merely complete physiological division. Further than such assistance as this information affords, reaction of degeneration has no other prognostic significance except that reactions alter for better or for worse and that therefore comparison of findings at different periods aids in prognosis. In addition to normal reactions on the one hand and the reaction of degeneration on the other, many modifications of these are found—absence or varying diminution of faradic response with briskness of direct current response; or response to faradism with slowness of all degrees in response to the direct current. Reactions which fail in any of these ways to fulfil the description of the reaction of degeneration would indicate partial nerve lesion, and of especial significance is sluggishness of response to direct current stimulation.

Complete unresponsiveness to any strength of electrical stimulus that can be administered during general anæsthesia is interpreted as indicating absence of contractile tissue, but before arriving at such conclusion many other facts must be considered.

In addition to severity of lesion, an electrical examination can often give information also as to the probable site of this. Thus, with injury to the nerve supply of an upper limb, in assessing the relative functioning powers of different muscles, electrical stimulation is more reliable than are attempts at eliciting voluntary contraction, and in this way it may afford valuable help in deciding whether the lesion is at the level of roots, trunks, cords, etc. Again, reactions may have a definite finality in diagnosis, as, for example, in flaccid hysterical paralysis where reactions are, of course, normal. Indeed, no investigation of a lower moto neurone lesion is complete without a detailed analysis of the electrical responses.

LOW TENSION CURRENTS

The therapy of interrupted low tension currents is largely complementary to massage and is applicable to conditions where it is desirable to induce muscular contraction by artificial means. These ought to form part of the treatment of lower motor neurone paralysis, of wasting of muscle secondary to joint affection, and in the prevention of wasting where an acute synovitis involves functional rest of a joint, as, for example, when applied to the quadriceps in the treatment of a traumatic synovitis of the knee. Indeed, in conditions of the latter kind it would sometimes appear that rhythmically and slowly repeated muscle contractions influence absorption of the synovial exudate. Where subcutaneous and intramuscular infiltration exists as a sequel of cellulitis or neglect of soft tissues in treating fractures, stimulation of muscular contraction can be a most efficient aid in reducing this. Electrical stimulation of muscle will also frequently help in the treatment of localised fibrositis or fibro-myositis and, applied to muscles which

overlie joints affected by capsulitis or bursitis, it is a valuable addition to other forms of treatment. It will be observed that in all these conditions there is a common factor, namely, a defect in local circulation, and it is probable that, in affording a circulatory stimulus, artificial muscular contraction has its main if not its sole metabolic rationale. In addition, the current acts on the skin in a manner similar to that of a counter-irritant.

The other method of employing low tension currents, namely, in their uninterrupted form, is still very largely empirical and, as is the case with most physical agents, they ought almost always to form a part of a prescription rather than be used by themselves. As has been stated, the direct current can be utilised in introducing external ions into the tissues. Through uninjured skin the introduction of extrinsic ions has been almost, if not entirely, abandoned. Into a surface, however, which is not covered with cuticle, such as an ulcer, an infected sinus wall, a corneal surface, or the mucosa of the uterine cervix or body, it is possible to introduce ions to a therapeutic depth. As this procedure is mainly used in local infection, the ion introduced is that of zinc. The passage of a direct current through tissues has the other effect of creating an ordered movement of tissue ions and it is probably in this way that the direct current acts upon a synovial effusion or an acute traumatic exudate around a joint; passed along a limb it has an effect upon the pain of perineuritis, e.g. of the sciatic nerve or affecting the brachial plexus; and, in conjunction with other means, it is very definitely useful in the treatment of fibrositis, where, for example, its application can be concentrated on a small area such as an external humeral condyle in "tennis elbow."

Where an electric current exists in a conductor there is always a conversion of electrical energy into that of *heat*. This conversion conforms to Jules' Law, and the amount of heat generated rises with the increase of two factors, intensity of current and its duration in time. In the body, much of this heat is dissipated almost as soon as it is generated, largely by the circulation, and unless its generation is more rapid than its dissipation the temperature of the tissues is, of course, not raised. As rise of temperature is in accordance with the amount of heat developed per unit of time, it follows that the rise of temperature is dependent solely upon the intensity of current. "Low tension" currents are limited to a comparatively small intensity because of the amount of ionic displacement giving rise to pain from stimulation of the sensory nerves or even to coagulation of tissues. The amount of heat developed is independent of ionic displacement; in unit time it varies merely as the strength of the current.

HIGH FREQUENCY CURRENTS

High frequency currents can rise to comparatively great intensities without massive transference of ions, probably because the current does not persist in one direction sufficiently long to allow of considerable ionic transference before its reversal occurs, ionic movement being comparatively slow. D'Arsonval first employed this modification of electrical currents in medicine, and an intensity of 300 milliampères was a considerable increase upon the 50 milliampères obtainable through the same size of electrodes by low tension current treatment. Twenty-five years ago, owing to certain modifications of plant, a strength of 2 or 3 ampères or more became attainable by means of the diathermy apparatus, and resulted in a more rapid generation of heat and consequently in the attainment of higher

temperatures in deeply placed tissues. Almost ever since, diathermy has been the physical agent by means of which the highest temperatures have been attainable in deep tissues and its therapy has been concerned with this aim. Its indications have been such conditions as call for a local rise in temperature, all of which conditions have already been mentioned either specifically or more generally.

One set of disease states for which diathermy has been recommended as being almost a "specific" is chronic infection of the intra-pelvic genitalia, the uterus and appendages in women, and the prostate in men. Intra-pelvic diathermy is recommended for such joint diseases as rheumatoid arthritis, even in those in whom there is no obvious pelvic infection. Technical details are not relevant here; suffice it to say that the claims made for this particular application of diathermy have not been, at any rate generally, substantiated.

In surgery, diathermy is employed as a means of coagulating tissue by the local generation of heat—either coagulation *en masse*, as of a growth, or "line" coagulation in front of an advancing blade. This differs from division with a sharp scalpel in that the divided ends of small blood-vessels and lymphatics are coagulated in the process of division, thus eliminating a great deal of hæmorrhage and some at least of the danger of extension of a growth.

SHORT- OR ULTRA-SHORT-WAVE THERAPY

One of the outstanding technical physical defects of even the most modern spark-gap apparatus lies in the fact that, as the alternating current is generated intermittently, any given period of time is largely unoccupied by passage of the current, as large a proportion as $\frac{49}{50}$ of the whole time during which the current is applied being thus unfilled. This technical difficulty in connection with deep heat generation has been overcome by the application of the thermionic valve to medical purposes, a procedure which is generally known as *Short- or Ultra-Short-Wave Therapy.*

Hitherto, the means of applying heat therapy have been limited to either the surface application of heat emanating from a hot body or to its generation in the tissues themselves by making use of the physical phenomenon whereby the "passage" of an electric current through a conducting medium is responsible for the generation of heat in that medium. The amount of heat so generated in a given time is directly proportional to the ohmic resistance of the medium where the current intensity is unvarying; the rationale has already been set out of the use of high frequency in the form of the diathermy current for the purpose of the generation of deep heat.

In all these methods of exposing the body either to the different types of electrical current or to radiation from the several parts of the electro-magnetic range, the skin is of necessity included in the parts affected by the treatment; sometimes it is the sole tissue of direct incidence of the agent employed, as in ultra-violet irradiation and in

practically all forms of direct heat application; in others, as in diathermy, it receives the major part of the current effect. Even X-rays and radium damage superficial tissues. Short-wave therapy offers a hope that the deep tissues may be affected by an agent which produces comparatively little effect upon the skin. Of recent introduction into medicine, the form of treatment to which this somewhat misleading name has been given has enjoyed a considerable vogue abroad. Its name is misleading because emanations of very much shorter wave-length are already in therapeutic use. Its wave-length range is, however, much shorter than the wave-lengths of the rest of the group to which it belongs (see diagram, page 5363).

The following is a brief and elementary account of the biophysical properties of this so-called short- or ultra-short-wave form of energy. In so far as this is known, its therapeutic application will also receive mention.

Considered *electrically*, matter can be divided into conductors and non-conductors or insulators. There is no perfect conductor or perfect insulator, and in this respect the different kinds of matter imperceptibly merge into one another from the highly conducting to the almost perfect insulator. Two metal plates separated by some highly insulating material, such as air, and connected in series with a source of electrical supply, constitute a condenser. In a condenser the non-conductor is known as the "dielectric." If the source of supply is a direct one, at the instant of sudden exposure of the plates to the source potential, although the circuit is not completed through conducting material, a momentary flow of current will be registered by a galvanometer, the current ceasing as soon as the condenser capacity is "satisfied." If the plates are disconnected from the current source and put into direct communication with one another by means of a wire incorporating a measuring instrument, a momentary current will be registered owing to discharge through the wire of the charge of electricity which had accumulated in the condenser unit. A condenser can therefore act as a store of electrical energy, the quantity stored being determined by the source voltage, the area of the plates, their distance apart, and a factor known as the "dielectric constant." This constant depends upon the nature of the material composing the dielectric. The dielectric is in a field of force, and the more highly insulating the material of which the dielectric is composed, the more closely can the plates be approximated and the greater therefore the capacity of the condenser unit, i e. the charge which can accumulate. No current can flow through the dielectric, and after the initial charging the electrical conditions of the condenser remain theoretically static. If, on the other hand, the plates are connected with an alternating supply, the charges on the plates alter in polarity with each alternation, and the dielectric is in a field of force of alternating direction. In these circumstances some of the energy of the field undergoes conversion in the dielectric. The mechanism of this conversion is obscure, but it is possibly associated with vibrations of dielectric atoms and molecules under the influence of the alternating field *One of its results is the* generation of heat. Under these conditions, with condenser plates connected with

a source of alternating supply, the condenser continually absorbs a certain moiety of energy from the alternating main, this small amount undergoes conversion into heat and the temperature of the dielectric accordingly rises. The conversion is known as the "dielectric loss." Technically, the lower the dielectric loss the higher the quality of the dielectric for alternating fields. Animal tissues do not constitute a "good" dielectric and for this reason there is considerable generation of heat when these form part of the dielectric.

In short-wave therapy that part of the body under treatment forms part of the dielectric of a condenser. The condenser plates correspond with electrodes but are separated from the tissues by considerable distances, and the intervening air forms a large proportion of the depth of the dielectric. The tissues therefore do not constitute part of an ordinary electric current circuit as in other forms of electro-therapy such as faradism, galvanism or diathermy; they lie in a field of force which is generated by charged condenser plates. The physical properties of this electric field are briefly these: when an alternating current "surges to and fro" in a wire, energy in the form of magnetic waves or whorls is generated around the wire, travelling into space at the speed of light, 300,000 kilometres per second, and constituting what are known as wireless waves. A current with an alternating frequency of 1,000,000 per second generates magnetic waves of this frequency, and as these are propagated through space at the above speed their wave-length from crest to crest is $\frac{300,000}{1,000,000}$ kilometre, or 300 metres. In short-wave therapy the frequency is from 20 to 100 times greater than this and the wave-length varies therefore from 3 to 15 metres. The wave-length cannot at present be shortened below this lower limit owing to the technical impossibility of generating high-frequency oscillations of sufficient energy with lower wave-lengths.

In the electro-magnetic range this "band" of radiation has wave-lengths considerably shorter than those which are commonly employed for transmission of messages (see diagram, page 5363). With a frequency of this order most dielectrics absorb a great part of the energy of the dielectric field and rise in temperature. This applies with special relevance to animal tissues and, when forming part of the dielectric, these show a considerable rise of temperature.

In a homogeneous dielectric the energy conversion is uniformly distributed throughout the whole dielectric field. If the dielectric is not homogeneous, but consists of several layers with different dielectric constants, the conversion is not distributed evenly. Above a certain wave-length this effect is not very pronounced; the lower the wave-length the greater is this effect of varying dielectric quality. A wave-length of longer than 20 metres is not thus affected and with such wave-length the different animal tissues would be more or less evenly heated were it not for the factor of ohmic resistance. Below this order of wave-length, with tissues of different dielectric constants, the conversion is unevenly distributed in the tissues, and the relative distribution throughout any set of tissues varies with the different wave-lengths. Thus, with one wave-length through a limb, bone may be most affected; with another, skin, muscle, or subcutaneous tissues. Each tissue probably has its own optimum wave-length. If the dielectric constant were known of every individual tissue in association with each wave-length and the ohmic conductivity under different high-frequency conditions, it would be possible exactly to determine beforehand the site of maximum conversion. This information is available only with regard to some tissues but is

continually and steadily expanding, and present knowledge enables us to use scientific therapy. In contra-distinction to these effects is the behaviour of diathermy currents—frequency 10^6—which are very considerably reduced in intensity by tissues of high ohmic resistance.

In a series of observed results of short-wave therapy the following conditions were very favourably affected after other forms of treatment had entirely failed: chronic coccal osteomyelitis, very old-standing and painful osteo-arthritis, cases of idiopathic sciatica of over one year's duration, persistent copious discharge from a deep-seated intra-peritoneal abscess (one case), pain as the result of intra-peritoneal adhesions, pain due to root irritation of spondylitis, and actinomycosis of the orbit (one case). One of the qualifications for inclusion in this series was a total failure to respond to other treatment.

The possible therapeutic field however, for short-wave therapy is a much wider one than is indicated in this list, and more or less reliable information is forthcoming of its beneficial effects in a great variety of diseases. These are said to include many deeply-seated and painful conditions of so-called rheumatic origin, and other infective and toxic states, such as gonococcal arthritis, empyema or pulmonary abscess, as well as asthma, pleurisy, angina pectoris, and certain diseases of the gall-bladder and kidneys. As yet, however, short-wave therapy is in its infancy, even in countries in which it has been accorded a much longer trial than it has in England.

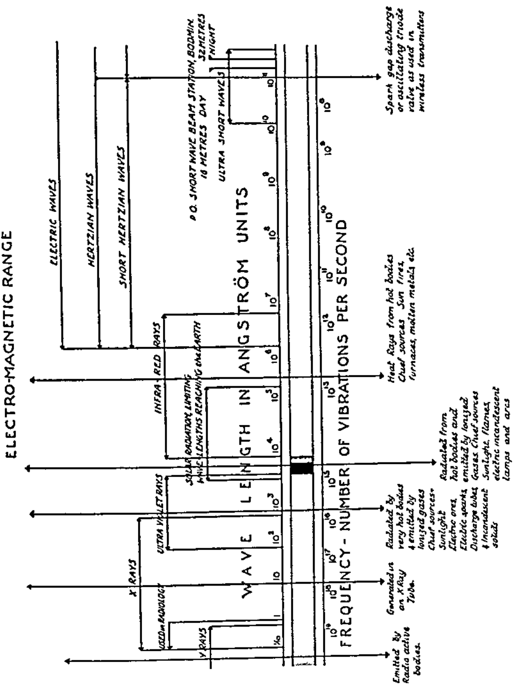
Considerable rise of *general temperature* can be produced by wave-lengths of the order of 15 metres under conditions of very high energy. Hyperpyrexia of 113° F. is possible, but whereas a general temperature of 107° F. is tolerable if not too prolonged, a rise to 110·3° F. or over is apparently fatal. This modification of ultra-short-wave therapy is recommended in the case of some very chronic diseases and as a substitute for other hyperpyretic agents such as the use of malaria infection in general paralysis of the insane.

There would therefore appear to be no doubt that ultra-short-wave radiations can raise the temperature of deeply-seated tissues. As already stated, it is probable that when sufficient knowledge exists with regard to the physical properties of tissues in relation to this agent, even a selective temperature effect will be at our disposal. Whether this agent has or has not specific effects beyond this, only experimentation will discover. Schereschewsky pointed to certain frequencies apparently possessing a superior lethal effect on micro-organisms and suggested the possibility of this being due to cellular resonance. He therefore experimented with inoculated tumours, selecting wave-

lengths which might be supposed to produce electro-mechanical oscillations in the tumour cells. Exposure of mice with inoculated sarcoma to wave-lengths of 4·4 metres was followed by recovery of 100 out of 400 animals, whereas all the 230 controls died—many of these, however, dying from bacterial infection. The possibility of heat effect is said to have been excluded. There are, however, strong reasons against the view that radiations belonging to this band of the electro-magnetic field have any specific effect beyond the production of heat.

ULTRA-VIOLET IRRADIATION

In addition to its protective function, the skin fulfils others of great importance. It is an organ of excretion and immunisation, changes in its circulation have congesting and decongesting influence upon deeply-placed structures, whilst, as Barber points out, "*irradiation of the skin may owe some of its undoubted general effects to an* indirect influence upon the endocrine autonomic system." The extremely limited depth of penetration of ultra-violet radiations must not therefore be necessarily held to set a severe limit to the therapeutic value of these radiations. The situation in the electro-magnetic range of the therapeutic band to which the above name has been given is indicated in the accompanying diagram.



(Reproduced by permission of the Science Museum, South Kensington, with addition of ultra short wave band)

from the nucleus. The characters of the atom of copper, hydrogen, mercury, etc., are determined by the numbers and arrangements of these charges, and, for each element, not only the number but the exact orbital arrangement is constant. The atom is electrically neutral when there is an equal number of positive and negative charges ; if an electron is lost from its planetary system the atom becomes a positively charged "ion" ; the acquisition of a supernumerary planetary electron renders it a negatively charged "ion." Vibrations (radiations) are originated as a result of changes in the atom ; whilst, on the other hand, vibrations,

on encountering an atom, may be themselves expended in the production of atomic change. More precisely, when a planetary electron moves nearer to the atomic "sun" or nucleus, or a supernumerary electron is acquired from space, an ether vibration is emitted; when a vibration encountering an atom is stopped (fails to penetrate further) the vibration energy is "absorbed" and one or more planetary electrons are displaced to a peripheral orbit or to space.

Ether vibrations must be of very small wave-length if they are to bring about these atomic changes. Whereas vibrations of $0{\cdot}75\mu$ and over will cause the atomic system as a whole to vibrate and thus give rise to heat energy, ultra-violet vibrations produced by centripetal movements of outer planetary electrons, when absorbed, will cause boundary electrons to move centrifugally or even into space. When vibrations of this order of wave-length (U.V.R.) encounter matter they may produce some or all of the following effects: (1) Electrons are divorced from the atom into space; emission of electrons from metallic surfaces *with production of radiation from these—photo-electric ionisation.* (2) The movement of electrons may be to outer orbits only; here they become unstable and so assume positions of greater potential energy, tending to revert towards the nucleus. If this centripetal fall occurs during irradiation, the phenomenon of "fluorescence" is produced; if after cessation of the irradiation, "phosphorescence" results. (3) There is, finally, the effect on complex molecules such as those which constitute living tissues. Molecular constitution is that of two or more atomic systems in which the various atoms, individually unsatisfied, are linked together by their peripheral electrons, the result being an electrically neutral arrangement. The effect on a complex molecule of radiations whose wave-lengths are of the order under discussion is a divorcement of boundary electrons into space, the complex molecule breaking up into smaller ones or even into its constituent atoms.

The main *source* of ultra-violet radiation is the sun. Much of the ultra-violet rays from this source are absorbed by pollution and moisture surrounding the earth's surface, and artificial sources become necessary. Only one, the electric arc, develops a temperature high enough to supply ultra-violet radiation in therapeutic intensity, and this is employed in two forms—the arc between carbons and the arc in mercury vapour. In the former the temperature of the negative carbon rises to a degree at which electrons are emitted at high velocity, encounter atoms of carbon, oxygen, hydrogen and nitrogen in the arc, and produce centrifugal electronic movements in these. Other, peripheral, electrons undergo a centripetal "fall" to take the place of the former and this results in emanation of energy of various wave-lengths. For each fall there is one wave-length and one wave-length only, resulting in characteristic "spectra."

Ultra-violet energy can be used for either its general or its local effects. In *general* exposure, although as yet its use is based almost entirely on clinical experience, it is interesting to attempt to assess the depth to which the rays penetrate the skin before absorption, and opinions vary widely on this point. Leonard Hill very definitely states that any effective intensity of wave-length shorter than 3000 Å is stopped at a depth of 0·5 mm., whilst Bachem and Kunz found that, of radiations with wave-lengths below 2800 Å, only 2·5 per cent pene-

trated skin tissue of a thickness of 0·1 mm. Under climatic conditions which permit of therapeutic intensities of solar ultra-violet radiation reaching the earth's surface, certain kinds of glass, in thickness suitable for windows, will *transmit* radiation of sufficient intensity for therapeutic purposes.

In *therapeutic* dosage, the only obvious effect on the skin is an erythema which begins about six hours after exposure and represents a mild inflammatory response to an "insult." Leonard Hill and Eidinow have obtained results even with doses which are too small to produce erythema. The only irrefutable effect in disease is that observed in *rickets*; and indeed this effect is used as a test of the biologically active rays in given sources. Exposure of foodstuffs to ultra-violet radiation will generate anti-rachitic properties in these. This is brought about through the elaboration of vitamin D. Associated with its antirachitic properties is the influence on *calcium metabolism.* The mechanism of the part taken by vitamin D. in calcium metabolism is obscure but probably lies in increased calcium absorption from the intestines. The other disease group which is almost certainly influenced by ultra-violet irradiation of the general skin is "*surgical*" *tuberculosis*, though proof of this is not so compelling as in the case of rickets. Of its effect in increasing the *hæmo-bactericidal* capacity of the tissues there is still less certainty, though here again there is ample clinical evidence pointing to increase in resistance as a result of general irradiation. These rays have undoubtedly *direct bactericidal* effects if the exposed organisms are entirely unshielded. Finally, much controversy has ranged around the question of their possible *tonic* action and of their prophylactic power to *increase immunity.* In the latter respect, clinical experiments on "colds" are entirely conflicting; whilst with regard to a possible tonic action, so long as there exists no adequate means of assessing relative degrees of fitness, opinion must be based upon evidence such as the statements of patients— factors so intangible as to be scientifically valueless.

PART XXXVII

DEEP X-RAY THERAPY

by

WALTER M. LEVITT

DEEP X-RAY THERAPY

CHAPTER I

Nature and Properties of X-rays

While it is not proposed to deal with the technique of X-ray therapy in this article, it is considered that some knowledge of the general principles governing X-ray treatment should be possessed by the medical man who may have charge of a patient undergoing this form of therapy. An attempt will therefore be made to describe in simple, non-technical language the properties and mode of production of X-rays, and their application in the treatment of disease.

X-rays consist of invisible electro-magnetic vibrations of exactly the same nature as visible light, though differing from it in wave-length. There is a wide spectrum of such electro-magnetic vibrations, ranging from the wireless waves at one end, with wave-lengths which may be reckoned in kilometres, to the gamma rays of radium at the opposite end, with wave-lengths estimated in ten-millionths of a millimetre (see fig. 2920). X-rays, in common with gamma rays, travel in straight lines. As produced from the X-ray tube, they originate at what may be regarded as a point-source, from which they travel as an ever-widening bundle or cone. It will thus be readily understood that the further the rays have travelled from their point of origin in the X-ray tube, the greater will be the cross-section of the cone. Incidentally, since the rays originate, for practical purposes, at a point-source, the dose delivered at various distances from that point will follow the law of inverse squares. X-rays, in so far as their clinical use is concerned, can neither be reflected nor refracted; that is to say, the rays comprising a single beam cannot be bent so as to focus on a given lesion. In this respect they differ from light in their behaviour, and where concentration of radiation on a given point is required, it is effected by directing several beams on to the required point from different aspects.

X-rays have the property of penetrating solid matter, although they become partially or completely absorbed in the process. The degree to which a given beam will penetrate matter depends upon two factors—firstly, the density of the material, and secondly, the penetrating power or "quality" of the beam itself. A very penetrating ray is known as a "hard ray," while a ray which is not very penetrating, and is accordingly easily absorbed, is termed a "soft ray."

Mode of Production.

X-rays are produced whenever electrons, or unit negative particles of electricity, which have been accelerated to a sufficient speed, are suddenly arrested in their path. In the X-ray tube the acceleration of the particles is effected by the application of very high voltages. The electrons, or negative particles, are produced at the negative or cathode end of the tube, while opposite the cathode is placed the positive terminal. When a high voltage is applied, the negative electrons are drawn towards the positive terminal, at a speed which will depend upon the voltage. Associated with the positive terminal is a solid block of tough

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While it is not proposed to deal with the technique of X-ray therapy in this article, *it is considered that some knowledge of the general principles governing X-ray* treatment should be possessed by the medical man who may have charge of a patient undergoing this form of therapy. An attempt will therefore be made to describe in simple, non-technical language the properties and mode of production of X-rays, and their application in the treatment of disease.

X-rays consist of invisible electro-magnetic vibrations of exactly the same nature as visible light, though differing from it in wave-length. There is a wide spectrum of such electro-magnetic vibrations, ranging from the wireless waves at one end, with wave-lengths which may be reckoned in kilometres, to the gamma rays of radium at the opposite end, with wave-lengths estimated in ten-millionths of a millimetre (see fig. 2920). X-rays, in common with gamma rays, travel in straight lines. As produced from the X-ray tube, they originate at what may be regarded as a point-source, from which they travel as an ever-widening bundle or cone. It will thus be readily understood that the further the rays have travelled from their point of origin in the X-ray tube, the greater will be the cross-section of the cone. Incidentally, since the rays originate, for practical purposes, at a point-source, the dose delivered at various distances from that point will follow the law of inverse squares. X-rays, in so far as their clinical use is concerned, can neither be reflected nor refracted ; that is to say, the rays comprising a single beam cannot be bent so as to focus on a given lesion. In this respect they differ from light in their behaviour, and where concentration of radiation on a given point is required, it is effected by directing several beams on to the required point from different aspects.

X-rays have the property of penetrating solid matter, although they become partially or completely absorbed in the process. The degree to which a given beam will penetrate matter depends upon two factors—firstly, the density of the material, and secondly, the penetrating power or " quality " of the beam itself. A very penetrating ray is known as a " hard ray," while a ray which is not very penetrating, and is accordingly easily absorbed, is termed a " soft ray."

Mode of Production.

X-rays are produced whenever electrons, or unit negative particles of electricity, which have been accelerated to a sufficient speed, are suddenly arrested in their path. In the X-ray tube the acceleration of the particles is effected by the application of very high voltages. The electrons, or negative particles, are produced at the negative or cathode end of the tube, while opposite the cathode is placed the positive terminal. When a high voltage is applied, the negative electrons are drawn towards the positive terminal, at a speed which will depend upon the voltage. Associated with the positive terminal is a solid block of tough

metal, usually tungsten, with which the electrons collide, thus producing the X-rays. The X-ray tube (fig. 2921) therefore consists of a cathode which contains the source of the electrons, and an anode with the associated block of metal which is known as the anticathode. The tube has to be completely evacuated, so that no current will pass save that carried by the electrons previously mentioned. The

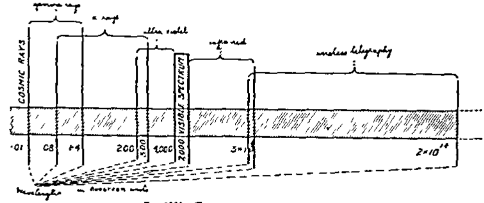


Fig. 2920.—The electro-magnetic spectrum.

electrons themselves are provided at the cathode by including in the latter a spiral of wire, which can be electrically heated to any required temperature by some external means, such as a battery or a transformer. It is found that when metals are made to glow, electrons are given off in a quantity which is dependent upon the

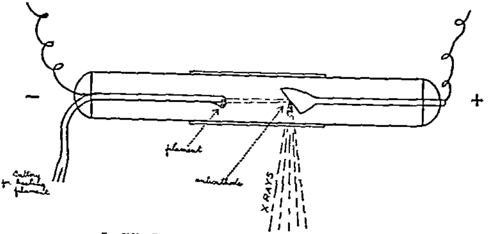


Fig. 2921.—Diagrammatic representation of an X ray tube.

temperature to which the metal has been raised. This furnishes a means of control of the current passing in the X-ray tube, by varying the temperature of the spiral.

It is found that the higher the voltage applied to the X-ray tube, the more penetrating is the bundle of rays emitted. More exact analysis of the beam, however, shows that, no matter how high the voltage, there is always an admixture of less penetrating, and even of very soft, rays present. These, as we shall see, can be removed or filtered off to a considerable extent, thereby greatly increasing the penetrating power of the residual beam. Voltages used in X-ray therapy vary from about 40,000 for superficial therapy to 400,000, or even higher, for

deep therapy. Very few machines exist at the present time, however, for voltages much higher than 200,000, at which voltage deep therapy is mostly carried out.

Filtration.

This is the process of separation of the softer, or less penetrating, components, as just explained. The beam is passed through a layer of metal, the thickness of which is so adjusted that it will absorb the less penetrating components, while allowing the more penetrating ones to pass through. For voltages up to 150,000, aluminium is generally used, the filter varying in thickness from one or two millimetres for 40,000 volts, up to five millimetres for 150,000. With voltages above 150,000, copper is the commonest filter, and for a beam produced at 180,000, a thickness of 0·5 millimetres of this metal is a suitable filter; while for a beam produced at 200,000, a thickness of about one millimetre of copper is necessary.

It may be of interest to indicate the order of efficiency of penetration of the more penetrating beams produced at, say, 200,000 volts, and suitably filtered. The efficiency varies somewhat with certain technical factors; but it may be said that, from a single beam of X-rays, the dose obtained at a point ten centimetres deep in the body is anything from one-quarter to one-half of that applied to the surface. Thus, in the irradiation of a carcinoma of the cervix uteri, under the best possible conditions, nearly one-half of the dose applied to each surface area or " field " will reach the cervix.

X-ray Protection.

It has been already indicated that the capacity of a material to absorb or stop X-rays is determined by its density. For this reason, lead, which is the densest substance in common use, is used to protect against X-rays, and fortunately it is capable of being worked with ease in thin layers. A layer of lead three or four millimetres thick is sufficient for practical purposes to protect completely against X-rays produced at 200,000 volts. It should be realised, however, that other substances of high density serve equally well, provided that a sufficiently thick layer is employed.

THE APPLICATION OF X-RAYS TO THE PATIENT

For the purposes of applying X-rays in treatment, there are two main requirements:

(1) The size and shape of the beam must be capable of perfect control, so that it can be adapted to the irradiation of any required area of the patient.

(2) The X-ray tube must be mounted on some form of carrying device so that the beam may be inclined with exactitude in any required direction.

For the purposes of the first requirement, namely, the control of the size and shape of the beam, two methods are commonly in use: (*a*) In the first method, an *applicator* is fitted to the X-ray tube, which takes the form of a box through which the beam must pass. The sides of the box are lead-lined, while the upper end, which is presented to the X-ray tube, is open. The bottom end, which comes in contact with the skin of the patient, is closed by a layer of wood, so thin as to have no appreciable effect on the beam. The closed end of the applicator bears the somewhat contradictory term of " aperture." Applicators are made in a great variety of sizes and shapes of aperture. Some applicators, one in position attached to an X-ray tube, are shown in figure 2922.

(*b*) In the second method of controlling the shape and size of the beam, the

protection is carefully built up to the required shape and size on the patient's skin, no applicator being attached to the tube. For this purpose, pieces of lead and lead-impregnated rubber are used, these being available in a great variety of shapes and sizes, so that, if necessary, the margin of a sinuous lesion can be faithfully followed. The pieces of lead are clipped together, and care is taken that a considerably wider margin of lead protection on the skin is provided than is necessary to cover the full extent of the beam emitted from the tube. When a skin field has been prepared for exposure in this way, the area to be exposed will appear in the centre of a wide margin of lead protective, as shown in figures 2923 and 2924

For the purposes of accurate direction of the beam, various methods of mounting the X-ray tube are in vogue, and in all good apparatuses means are provided for measuring the angle of inclination in any direction.

X-ray Dosage.

A great many methods have been employed for the measurement of X-rays. Some of the best known have depended on colour changes induced in certain

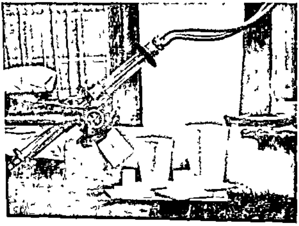


Fig. 2922.—APPLICATORS FOR X RAY TREATMENT. ONE IN POSITION ATTACHED TO THE X-RAY TUBE.

chemical substances on exposure to the radiations, and of these the classical examples are (*a*) the Sabouraud and Noiré Pastille method—which gave us the "B Unit", and (*b*) the Holznecht method—which gave us the "H Unit." Other methods have depended upon the photographic changes induced by the rays. All these methods are now obsolete, though they have a certain historic interest. All are inaccurate, and in certain circumstances may be dangerous. They have been superseded by the scientifically-exact ionisation method of measurement.

The principle of the ionisation method of X-ray measurement is simple. Air is normally a non-conductor of electricity. When, however, it is exposed to X-rays, its molecules are split up into their constituent positive and negative ions, which are capable of transporting electric current. Now it is found that the number of ions produced per second in a given quantity of air is dependent upon the strength or intensity of the applied radiation. The amount of electrical charge, therefore, that can be transported per second will depend upon the strength of the radiation. Here then we have an accurate means of estimating the strength of a source of radiation. In practice, the given volume of air is contained in a so-called ionisation chamber, which is usually about the size of a man's thumb.

Fig. 2923.—X-RAY TREATMENT OF AN AXILLARY GLAND. THE FIELD TO BE EXPOSED HAS BEEN OUTLINED ON THE SKIN

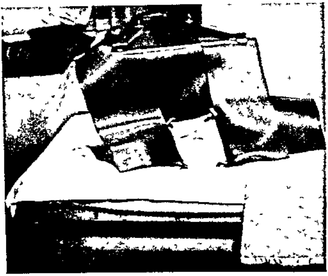


Fig. 2924.—THE FIELD READY FOR EXPOSURE. THE IMMEDIATE SURROUNDINGS OF THE FIELD ARE PROTECTED BY LEAD FOIL ENCASED IN MACKINTOSH (WHITE IN PHOTOGRAPH); THE REMAINDER OF THE PATIENT IS PROTECTED BY LEAD RUBBER (BLACK IN PHOTOGRAPH).

Fig 2925.—THE PRINCIPLE OF THE IONISATION METHOD OF X RAY MEASUREMENT.
When the air in the chamber becomes conducting, the charge on the electroscope is [illegible] by it to earth at a rate proportionate to the intensity of radiation.

Different instruments differ in the method of measuring current transported in the ionisation chamber as a result of the application of the X-rays, but all the standard instruments give a high degree of accuracy—within one or two per cent. An ionisation instrument is diagrammatically illustrated in figure 2925.

X-ray Dosage Units.

An International Unit of X-ray Dosage—known as the "r" or "röntgen" —has been elaborated, based upon the ionisation method. Unfortunately, the "r" leaves something to be desired for practical purposes, in that the biological effect of a given number of "r" varies with the quality of ray. At 200,000 volts, and with an appropriate filter, a dose of 800 "r" applied at one exposure will produce a well-marked skin erythema.

Unit Skin Dose and Erythema Dose. It is often convenient to have a biological unit of dosage, and for this purpose the unit skin dose ("U.S.D.") is employed. It is defined as that quantity of radiation which will produce a specified grade of erythema when applied at one exposure to healthy abdominal skin. It should be noted that a dose which will produce an erythema at *one* exposure will, if divided into *several fractions* over a period of several days, fail to do so. The writer worked out the corrections that have to be made if the dose is spread in this way, and he found that when spread into equal daily fractions over a week, about 1·6 times the U.S.D. is required to produce an erythema, while in equal daily fractions over a fortnight, the erythema dose is equal to about 2·2 unit skin doses.

CHAPTER II

Effects of X-rays on Living Tissues

The fact that X-rays could produce changes in living tissues was observed very soon after their discovery. Thus, in a communication to *Nature* in March 1896, barely two months after the announcement of Röntgen's epoch-making discovery, Edison and others commented upon the effects of X-rays upon the eyes; and in the same year several accounts were published describing the effects of X-rays upon the skin. These and similar observations soon led to speculation as to possible therapeutic effects, and very quickly efforts were being made to test their value in this direction.

As might be expected, lesions of the skin, both malignant and non-malignant, were the first to be submitted to experimental irradiation; but investigations on the bactericidal powers of X-rays were also carried out by several workers quite early. With the progressive increase in the power of generating apparatus, and the production of more and more penetrating radiations, attempts were made to treat more deeply-placed lesions, and a vast literature has grown up dealing with the effects of X-rays on normal and abnormal organs and tissues in the human body. We shall here discuss briefly some of the more important of these effects of the radiations, and in somewhat greater detail the characters, diagnosis and treatment of some of the injuries that may be produced.

General Characteristics of X-ray Effects.

Every observed effect of the action of X-rays upon living tissues is a combination of two factors—the injurious effect of the radiations upon the irradiated tissue, and the defensive and reparative reaction of the organism to the injurious stimulus. Every application of X-rays to living tissues in sufficient dosage to produce appreciable changes must involve an injury to some, though not necessarily all, of the elements of that tissue. There is an important difference, however, in this respect between X-rays and other injurious stimuli, namely, that the dose of radiations, and accordingly the degree of the injury, can be very accurately controlled, even when deep regions are being irradiated; and moreover, the application of the injurious stimulus is unassociated with the complicating factors of mechanical trauma and sepsis. The immediate reaction resulting from the application of a dose of X-rays is very similar to a bacteriogenic inflammation, with the difference, however, that in the case of irradiation the causal factor has been withdrawn, and unless excessive doses have been given there is no destruction of tissue and no pus formation. The process can best be studied in the case of the skin and subcutaneous tissues. It is found that of the classical characteristics of inflammation, redness is well marked, heat and swelling only slightly so, and pain, except when excessive dosage has been given, is completely absent. The inflammatory reaction persists for a few days and then gradually subsides. Histologically the effects are similar to those observed in pyogenic inflammation,

and this suggests that some, if not all, of the same defence mechanisms are involved. This may explain the value of X-rays in certain acute and chronic inflammatory conditions, as inducing a greater marshalling of the defensive forces, and over a wider area than is provoked by the infecting agent alone. In the chronic inflammatory lesions, at any rate, the effects of X-ray treatment may be interpreted as the production of repeated attacks of acute inflammation of moderate and strictly controlled grade at any required intervals. The method is thus in some respects comparable with the artificial production of hyperæmia in the treatment of chronic inflammatory conditions. It is possible that the effects of X-rays in preventing keloid formation in fresh scars may also act by assisting the tissues in this way to deal with an infecting organism of low virulence.

There are two important special characteristics of X-ray action that require to be mentioned: (1) Latent period; and (2) Cumulation of effect.

Latent Period. When a Unit Skin Dose of X-rays is applied to the skin, the typical erythema does not at once become apparent, but an interval or "latent period" of from four days to three or even more weeks elapses before it occurs. During the latent period there is usually no evidence whatever that a large dose of X-rays has been applied, although in a few cases a transient early erythema may occur a few hours after the delivery of the dose. Even when the dose has been sufficient to cause a severe burn there is still a latent period which is never less than three and rarely less than five days. The duration of the latent period depends upon several factors, among which the most important are the quality of the ray, and the quality and pigmentation of the patient's skin. The magnitude of the dose is of less importance.

Cumulative Effect. Recovery from a dose of X-rays is slow and takes several weeks to reach its maximum. This is true even when no appreciable effects have been produced on the tissues. Moreover, it is probable that when any considerable dose of X-rays has been given to a tissue, recovery is never *quite* complete although the residual effect may be so small as to be negligible. When further X-ray treatment has to be considered, however, the possible residual effect has to be taken into account, and dosage may have to be reduced. Failure to appreciate the importance of this cumulation of effect has accounted for a great many of the disasters which have from time to time occurred in the past as a result of X-ray treatment. Thus, in the treatment of lupus, and also of hyperthyroidism, it was not uncommon for fifty or more doses to be given at short intervals over a period of a year or so. The cumulative effect frequently resulted in severe skin changes, such as will be described further on in this section. The damaging effect of X-rays on the skin and blood of X-ray workers also results from the cumulation of small doses over long periods.

It will readily be understood from what has been said concerning the cumulative effect that a tolerance to X-rays cannot be induced in a tissue by careful gradation of dosage, although, curiously enough, it is true that the *body as a whole* can be gradually accustomed to increasing doses. Thus, in the "bath method" of treatment of extensive deposits of sensitive growths in the abdomen and chest, the patient may eventually come to tolerate with little or no inconvenience a dose of X-rays applied to the whole abdomen which, if applied without previous "desensitisation," would lead to very severe, if not fatal, results.

THE EFFECTS OF X-RAYS UPON THE SKIN

The effects of X-rays upon the skin, as upon the blood, differ very considerably according to whether the rays have been applied within a short space of time, as in correct therapeutic application (" acute exposure "), or in repeated small doses over a long period of time, as in obsolete methods of X-ray therapy and in occupational exposure (" chronic exposure "). A great deal of confusion exists in many of the descriptions of the effects of X-rays upon the skin which have been published, and it is important that the difference just referred to should be clearly grasped, more particularly as the subject has important surgical applications.

It may help us to understand the difference in the effects of acute and chronic exposure to X-rays if we consider the effects of some more familiar, potentially injurious, physical agent, applied with different intensities and time distributions. Let us consider the behaviour of the skin to simple physical pressure. If we compare the effect of pressure upon an area of skin sustained continuously for several days with that of intermittent pressure, of lesser intensity, but extending over a long period, we find that there is a great difference in the results. Thus the former, continuous pressure, results in an atrophic, and finally a necrotic, process, while the latter, which is exemplified by the pressure of a tight shoe, results in a hyperplastic process—a corn. What really happens is, of course, that the intermittent application of sub-maximal stimuli in the latter case has resulted in such an exaggerated reparative and protective process that the latter has completely overshadowed in the clinical picture the damage done by the physical agent; and this is precisely the basis of the difference between acute and chronic effects of X-rays. The effects upon the skin of acute exposure to X-rays are described as *Acute X-ray Dermatitis*, while those of chronic exposure are described as *Chronic X-ray Dermatitis.*

Acute X-ray Dermatitis. This condition follows the application, over a short space of time up to a few weeks, of moderate and large doses of X-rays such as are used in X-ray therapy. With small doses no visible effects are produced. As the dose is increased, however, a point is reached at which, after a due latent period, epilation of hairy parts is produced. At the same time it is observed that the activity of the sweat and sebaceous glands has been diminished. After an interval of several weeks, the hair grows again, and partial though not complete, restoration of the secretory glands occurs. When soft rays are used the hair rarely fails to grow again, and with hard rays failure of re-growth is almost unknown. No fibrotic changes occur in the skin or deeper tissues. The skin effect just described is known as the *first degree* of acute X-ray dermatitis. When the dose of X-rays is still further increased, the next effect observed is the production, again after the proper latent period, of an erythema. This erythema varies with the dosage applied, from a faint pink to a dark bluish-red. It is very accurately limited to the area exposed to the rays. It persists for several days, to be followed by pigmentation which varies in intensity with the characters of the skin of the patient. Finally, some weeks after the delivery of the dose, desquamation occurs, and the skin is restored to an approximately normal condition. A brownish stain, however, may remain permanently over the area treated, and some permanent dryness is constant. When hard rays are used, permanent epilation is very rare, although it is more frequently observed after the use of soft rays. No fibrotic changes,

or only very slight ones, are produced. This reaction is known as the *second degree* of acute X-ray dermatitis. The *third degree* of acute X-ray dermatitis commences with a dark bluish-red erythema which rapidly proceeds to the stage of vesication. Vesicles may be small and discrete, or they may run together to form bullæ. Slighter cases of third degree dermatitis heal with great rapidity after the vesicles have burst, and scarring is slight or completely absent. Pigmentation, however, is more marked, and its distribution more irregular, than in the earlier degrees. Patchy permanent epilation is common. In the more severe cases, raw areas exposed by the bursting of the bullæ become infected with pyogenic organisms and healing may be long delayed. The condition then assumes the characteristics of an X-ray burn. The *fourth degree* of X-ray dermatitis is characterised by deep ulceration—the true X-ray burn.

An X-ray burn may follow a severe third-degree dermatitis, or it may follow the lesser degrees when a factor of serious mechanical, thermal or chemical irritation has been superadded. Thus the application of an irritant liniment, or of a very hot fomentation, may convert a first-degree dermatitis into a typical X-ray burn.

An X-ray burn either follows closely in its extent the area treated—that is to say, its outline usually forms some geometrical pattern—or it is found upon an area of skin which bears evidences of heavy irradiation (epilation, dryness, pigmentation, and often telangiectases). Since the skin is more sensitive than the deeper tissues, the edges of an X-ray burn are not undermined; on the contrary, the wall of the ulcer is clear-cut, or even bevelled. *This is an important point in differential diagnosis.* The floor of the ulcer is covered by a typical smooth deep green slough. There is often a narrow rim of hyperæmia of the skin at the margin of the ulcer. In extensive serious burns (now practically never seen), hard, wooden, greyish honeycomb crusts may be found in the depths of the ulcer, which take months to separate.

Late Effects.

(1) *Telangiectases, or spider angiomata,* often appear after an interval of months, or even years, after very large doses of X-rays have been given. They vary in severity from a few isolated spots which are scarcely visible, up to a closely woven bright red network covering the whole region of skin exposed. They sometimes improve considerably quite spontaneously, but they rarely fade completely. They may appear without warning on an irradiated area of skin which has presented a perfectly normal appearance for months, or even years, after the X-ray treatment.

(2) *Solid œdema of the skin.* This is a condition in which the skin presents a rubbery thickening most commonly affecting dependent regions, such as the submental region. It usually occurs several weeks or months after the treatment. It may clear up either partially or completely, or it may persist permanently.

(3) *Late necrosis.* Months or even years after intensive irradiation, an ulcer may form as a result of trauma or sepsis, and present similar characteristics to those of the acute X-ray burn.

Chronic X-ray Dermatitis. This is mainly an occupational condition affecting the hands, and sometimes the face and other regions, of radiologists and other X-ray workers. It is characterised by dryness of the skin, epilation, loss of elasticity, and sometimes by a condition of painful hyperæmia. In the later stages,

cracks and fissures appear in the skin which are extremely painful and difficult to heal, and in this stage also hyperkeratosis occurs. The latter process is evidenced by the occurrence of multiple hard warts, often of the cauliflower type, and by severe and painful changes in the nails. The nail-fold proliferates and at the same time shows a tendency to ulceration, while irregular overgrowth of the nail-bed occurs, as a result of which the nail may be shed. Chronic X-ray dermatitis often terminates in epithelioma, which may have its origin in a fissure or wart.

X-ray Carcinoma. This is a common termination of chronic X-ray dermatitis, but is rarely, if ever, observed as a result of acute X-ray dermatitis. It may therefore be said that X-ray carcinoma never results from correct therapeutic applications of X-rays. X-ray carcinoma is often multiple, and metastasis to glands is frequent. Occasionally visceral metastases occur. Histologically the condition is a typical squamous-celled carcinoma.

Effect of Ultra-violet Radiation in X-ray Dermatitis. It is important to note that all the effects of X-rays described are intensified by exposure to ultra-violet irradiations. Serious results have been known to follow sun-baths of areas of skin to which erythema doses of X-rays had previously been given.

Treatment of Radiodermatitis.

(1) *Acute X-ray Dermatitis.* (*a*) *During the course of the X ray treatment* certain important precautions have to be observed: All forms of irritation—mechanical, thermal, and chemical—must be rigorously avoided, and the patient must be warned against friction from collars, corsets, etc., and against the use of hot or very cold applications, or of irritant ointments or liniments. It is especially important to avoid any applications to the skin containing heavy metals, however bland or non-irritant they may be, since secondary radiations would be excited in such preparations, thus intensifying the effects of the rays. Itching may be relieved by dusting with a simple starch powder. Some authorities have recommended anointing the skin of the part exposed with fats, such as pure unsalted lard. Such preparations in the author's experience, although they may relieve symptoms for the time being, tend to intensify the erythematous reaction.

(*b*) *After the appearance of the X-ray effect,* the treatment will depend upon the severity of the X-ray effect. For the ordinary second-degree erythema, no treatment is usually required beyond the precautionary measures already detailed. Itching may be treated as before by dusting with starch powder, or, after the completion of the irradiation, a zinc oxide, bismuth and starch powder may be employed. If *blisters* occur, they may be treated by the application of cycloform ointment (Bayer), or, if the vesicated area is in danger of infection from a neighbouring septic focus, a weak preparation of flavine in paraffin, 1 in 2500, may be employed. (It is important that no spirit be used in making up this latter preparation.) Most of the deliberately produced vesicating reactions heal with great rapidity in the course of a few days. If, however, there is a tendency to delay in healing, it is a good plan to alternate the local applications. For this purpose, the flavine in paraffin may well be alternated with linimentum calaminæ. The oily preparation of calamine is advised in preference to the watery one in order to avoid the sticking of dressings. Sometimes it will be found that an X-ray reaction is much aggravated by irritation from discharges from foul fungating ulcers. In such cases, a castor oil preparation, such as equal parts of zinc oxide and castor oil, forms a valuable protective dressing.

True X-ray burns are now, happily, rarely seen ; but when they occur, they offer great difficulty in treatment. Pain is usually a dominant feature and may necessitate the use of cocaine locally. This drug is soluble in castor oil and may be used in this medium in combination with flavine, 1 in 3000, as an antiseptic. Quite weak strengths of cocaine, e.g. 1 per cent, may prove effective in relieving pain, and, where wide areas are involved, the possibility of absorption, and consequent poisoning from the drug, must not be lost sight of if stronger preparations are used. Immobilisation of the affected region should be carried out as far as possible

When the acute inflammatory stage has passed, healing may often be expedited by the application of a powerful astringent, with the object of forming a surface coagulum. For this purpose, a solution of tannic acid, 1 per cent in mercuric chloride, 1 in 2000 may be used A piece of gauze is accurately cut to the shape of the ulcer, and is soaked in the astringent preparation. It is then carefully applied to the surface of the lesion A black coagulum is formed which should not be disturbed so long as the lesion remains free from evidence of inflammatory reaction. If there is the slightest evidence of inflammation, the dressing should be removed the ulcer cleaned up, and a fresh dressing applied. If the ulcer fails to heal in spite of all efforts at treatment, excision of the ulcer-bearing region may have to be carried out.

(2) *Chronic X-ray Dermatitis.* The avoidance of chemical irritation is of special importance in this condition ; indeed, some authorities have regarded the irritation resulting from frequent immersion of the hands in developing and fixing solutions as an important ætiological factor. For the fissures, Finzi has recommended the use of "Durofix," a transparent cement manufactured by the Rawlplug Company. Isolated warts should be excised as soon as they have formed. Where they are multiple, however, excision may be impracticable, and discomfort arising from them may be mitigated by keeping them well filed down ; an ordinary nail file can be used for the purpose. Radium should never be used in treating them. *Telangiectases*, if discrete, may be treated by electro-coagulation.

In every case of chronic radiodermatitis, the possibility of carcinoma supervening should never be lost sight of, and in the presence of a suspicious area which fails to yield to simpler measures the only safe course to adopt is free and wide excision, followed if necessary by plastic surgery.

Chronic ulcerative lesions, whether resulting from acute burns or late necrosis, or occurring in the course of chronic radiodermatitis, are best treated by excision and plastic surgery. The whole subject of the surgical treatment of X-ray injuries is fully discussed in an admirable paper by Gillies and McIndoe (*British Journal of Radiology*, June 1933). These authorities stress the fact that excision should not be carried out too early, lest the full extent of the mischief be not appreciated. It is important that all diseased tissue should be removed, and if sufficient time has been allowed to elapse, the margin between the diseased and the healthy tissue is not difficult to define. Indeed there is often a definite cleavage plane. *The indications for operative treatment* are given as : (*a*) Pain ; (*b*) Deformity due to contraction ; (*c*) Cosmetic considerations ; and (*d*) Malignant changes.

The operative treatment falls naturally into two stages—first, the removal of the damaged tissue ; and second, plastic repair. In the majority of cases, both stages are carried out at the same operation ; but in the presence of sepsis, it may

be advisable to allow the wound to granulate before proceeding to the second stage. The use of the diathermy knife is recommended in the latter type of case.

(3) *X-ray Carcinoma.* While it is true that in a great many cases small X-ray carcinomata have been removed locally and the patients have remained well without recurrence, the balance of opinion undoubtedly favours free and wide excision. An incomplete local operation is more likely to be successful where the growth has arisen from the handling of small radium applicators. In such cases the main intensity of the carcinogenic agent has been very local in its operation, and the damaged tissue is therefore likely to be more limited in extent. Where, however, the growth has followed chronic exposure to X-rays, the process is likely to be much more extensive, and the more radical method would seem to be indicated.

The surgical treatment of X-ray carcinoma has been studied, especially by Sampson Handley, and the following extract is quoted from an article by him in Colwell and Russ's book, *X-ray and Radium Injuries:*

"The experience of any one surgeon in the treatment of X-ray carcinoma is necessarily limited, but it would appear that the bad prognosis of the disease is due largely to dilatory and incomplete operations for which the reluctance of the patient is perhaps mainly responsible. What has usually happened is that a series of small local excisions of warts or incipient carcinomata is undertaken over a period of years. Next, perhaps, a finger is removed. At this time, the axillary glands are enlarged, but the fact that the glands may be merely of septic origin is allowed to cast a pink haze of optimism over the menacing, but more likely, alternative that they are neoplastic. An axillary dissection is finally undertaken too late, and recurrence in the supra-clavicular glands or in the lung terminates the case.

"In my opinion, if a suspicious warty area is found to be a carcinoma, the patient's safety demands a complete gland dissection, so soon as the least glandular enlargement can be detected in the axilla or in the supra-trochlear gland on the affected side. The precaution is wise even in cases where the glands are normal to palpation, though it cannot then be so strongly urged. The object of the operation is to cut the main line of dissemination at an early stage. When once this has been done by the method now to be described, the disease is no longer free to range over the body. It is confined in its spread to the region of the forearm and hand. Here any subsequent local manifestations can be dealt with at leisure by limited local operations, with the loss of the forearm as the most serious ultimate forfeit that is likely to be demanded.

"Since in nearly all cases the first gland to be invaded is the supra-trochlear gland which lies on the internal intermuscular septum an inch or two above the medial epicondyle, a simple axillary dissection will not meet the case. Not only should the supra-trochlear gland be removed, but with it and in one piece should go the trunk-lymphatics which connect it with the axillary glands and the axillary glands themselves. The incision required begins at the junction of the anterior and medial walls of the axilla, passes across the front part of the axillary vault one inch behind the edge of the great pectoral to the insertion of that muscle, and continues down the medial side of the upper arm in a straight line to a point just above the internal epicondyle.

"In the brachial part of the incision, the skin and a thin layer of subcutaneou

fat are reflected a little so as to expose a band of the deep fascia an inch wide extending from the supra-trochlear gland to the axilla. The gland is dissected out, not cleanly but with a sheath of the surrounding fat, and from below upwards. Above, it is left in continuity with the exposed band of deep fascia, the edges of which are now defined by careful incisions through the fascia. It is now easy to strip up the fascia from the underlying muscles, nerves and vessels as far as the axilla but leaving it still in continuity with the axillary tissues. The opening up of the axilla and the removal of its glandular and fatty contents is the next step. It is not necessary to divide either the great or the lesser pectoral in order to do this satisfactorily The anterior axillary wall is first cleared, and a right-angled retractor passing immediately behind the great and lesser pectorals lifts these muscles out of the way and permits the vein to be cleared along its whole length, and the apical glands of the axilla (sub clavicular glands) to be reached and removed The inexpert operator is almost certain to leave these glands behind.

"The further steps in the axillary clearance need no special description, but when the intercosto humeral nerve is exposed it should be injected with alcohol before division as a precaution against post-operative neuralgic pain.

"The dissection throughout should be a gentle and delicate one, since it passes in close proximity to the brachial plexus and its main branches. Even with these precautions brachial neuralgia may be troublesome for some little time and may need sedatives. In the writer's experience no other complication has followed the operation.

"The portion of tissue removed is a single piece, consisting of the axillary tissues connected by a band of fascia with the supra-trochlear gland.

"Two cases of X-ray carcinoma treated in this fashion remain well after two years In one of them the supposedly 'septic' glands showed massive deposits of carcinoma One case was that of a distinguished British radiologist, the other of a Portuguese radiologist referred to the writer by Professor Regaud of Paris. A third case, upon the writer's advice, has recently been treated in this country upon the same lines."

The use of radium in the treatment of X-ray carcinoma has sometimes been advocated. It cannot, however, be too strongly emphasised that in the treatment of the primary growth this is a dangerous and unjustifiable method. In the case of glandular metastases, however, in regions in which the tumour bed has not suffered exposure to radiations, X-ray and perhaps radium therapy is a rational method of treatment.

THE EFFECTS OF X-RAYS UPON THE BLOOD

(1) *Therapeutic Exposure to Radiations.* The effects produced by X-ray treatment upon the blood will, of course, vary with the dose applied and with the volume of body tissue exposed. Small doses, such as are applied in the treatment of the chronic inflammatory and other non-malignant conditions, produce no appreciable changes in the blood picture. Large doses, on the other hand, especially if they are applied to extensive regions, produce marked and characteristic effects. These affect mainly the leucocytes, but in certain cases the red cells and hæmoglobin may also be affected. The changes in the formed elements are as follows:

Red Blood-Corpuscles. A slight increase in the number of the erythrocytes may occur after irradiation, but in patients who are already anæmic after large

doses a fall is observed which may be considerable. Polychromatophilia is frequent in these cases, anisocytosis and poikilocytosis less so. Megalocytes and megaloblasts are rarely observed, and then only after full doses in patients in whom anæmia is severe at the beginning of the treatment. The changes in the red cells reach their maximum 7 to 10 days after the irradiation.

Hæmoglobin. The hæmoglobin value is slightly increased with small and moderate doses. After full doses, a fall in the hæmoglobin is constant, and is the more marked the weaker the patient. The fall in hæmoglobin is always less than the decrease in number of the red blood-corpuscles. The colour index is therefore increased. This increase reaches its maximum after 8 to 12 days and usually returns to normal in about 3 weeks.

Leucocytes. Even after moderate doses, a fall in the total number of leucocytes is observed. The fall occurs rapidly, and reaches maximum about the fourth day after the irradiation. The total white count may fall as low as one-third or even one-fifth of the original count, i.e. to 1500 per cubic millimetre. The lymphocytes are those most affected. While further decrease in the number of the other cells usually ceases after a few days, the lymphocyte count may continue to fall for three weeks after the irradiation. The final lymphocyte count may be as low as 200 (normal being about 3000). Recovery in the lymphocyte count is gradual and is usually complete in about two months, after which a relative and absolute lymphocytosis may occur. No differences are observed in the behaviour of the small and large lymphocytes.

The neutrophils may show an initial increase (the occurrence of which is denied by some authorities), followed by a rapid fall in number. The nuclei tend towards the parent-type myelocytes, and even, though rarely, premyelocytes may be seen in the circulating blood. The occurrence of either of the latter types of cell is said to be of bad prognostic import.

The eosinophils at first show a fall in number, later an increase. The increase reaches its maximum in 4 to 5 weeks, when a relative and absolute eosinophilia may occur.

The large mononuclears may remain unchanged in their percentage ratio to the total leucocyte count, and therefore show an absolute decrease in number. Frequently, however, they are decreased to a greater extent and may even disappear from the blood.

The leucocyte count should be completely restored to normal 3 to 4 months after the irradiation. Delay in the return to normal is said to give a bad prognosis.

The clotting time (see Vol. I, page 820).

(2) *Chronic [accidental] Exposure to Radiations.* Changes have frequently been described in the blood of radiologists and of the personnel of X-ray departments, and in some cases the anæmia has been progressive and has ended fatally. The total leucocyte count is at first not greatly affected, but later it is reduced in moderate cases to 5000 or 6000, the reduction affecting principally the myelogenous elements. The lymphocytes are at first almost constantly increased in number, the count frequently being as high as 4000 or more. In the fatal forms the total leucocyte count may be as low as 1500, of which the lymphocytes may form about 40 to 50 per cent.

The *eosinophils* may be unaffected, they may be increased or reduced in number, or they may be altogether absent from the slide.

The *red cells* are unaffected except in the severest and fatal forms, when the red count may fall as low as 1,000,000.

The *colour index* is increased in cases of moderate severity, but in the severe cases it is reduced, and in fatal cases may fall as low as 20 per cent.

The occurrence of infective processes in these cases is very serious, and even slight infection may lead to a fatal issue.

In the severe grades, even the complete cessation of all X-ray work will often fail to restore the blood picture to normal, and in the worst cases the changes are progressive in spite of every treatment and precaution.

It is said that the earliest sign of blood injury due to X-rays or radium is a disturbance of the normal ratio between the polymorphonuclear and mononuclear cells, the numbers tending to become equalised. Thus a count of 48 per cent of mononuclears (including all lymphocytes) and a similar number of polymorphonuclears, even in the absence of a total leucopenia or other change, should be regarded as suspicious of X ray injury. In these cases a rest from radiological work, even of only a few weeks' duration, will often result in the return of the blood count to normal.

EFFECTS ON SPLEEN AND LYMPHOID TISSUES

Spleen (see Vol. I, page 820).

Lymph Glands The changes which occur in the lymph nodes after irradiation are of the highest importance in connection with the treatment of carcinoma. The importance of the lymphocyte in the limitation of the cancer process is now well recognised, and if, as is often stated, by heavy radiation we rob the lymph glands of their lymphocytes, we are breaking down one of the principal barriers to the dissemination of the cancer.

Heineke in 1905 described destruction of the lymphoid follicles, destruction of lymphocytes throughout the gland, and the occurrence of epithelioid cells following radiation. He stated, however, that complete restitution could occur after moderate doses These observations, as applying not only to lymph glands, but to all lymphoid tissue, have received fairly general acceptance.

More recently a good deal of work has been done on this subject by Murphy and Nakahara, and by Ewing These authorities have found that so far from causing a destructive effect on the lymphoid cells, proliferation of the lymphocytes is induced by radiation. Ewing emphasises the resistance of normal lymphoid tissue to radiations. Simple hyperplasia of the tonsil, for instance, only yields to large doses. Even after very heavy doses, squamous carcinoma cells may be found to be necrotic, while lymph follicles persist or even increase in number. Ewing describes the following changes in the lymph glands after the administration of large doses:

(1) Transformation of the germ centre into a small compact ring of flat cells resembling squamous epithelium.
(2) Replacement of the germ centre by lymphocytes.
(3) Obliteration of follicles, but persistence of lymphocytes.
(4) Reticulum cell hyperplasia.

As pointed out by Quick and Cutler, these observations "encourage the preservation of lymph nodes in the neighbourhood of squamous carcinoma when not

invaded, and their heavy irradiation when they are invaded. They further widen the breach between those who extirpate normal cervical lymph nodes in 60 per cent of the cases of lip carcinoma, and the radiologist who conserves these barriers against cancer intrusion when uninfected, and plans to control them when infected."

EFFECTS UPON THE GASTRO-INTESTINAL TRACT

Mouth and Throat. Erythematous reactions may be produced in the mucosa of the mouth and throat resembling those produced in the skin. Unlike the skin reactions, however, they are accompanied by tenderness and pain on mastication and swallowing, which in the worst cases may be so severe as to prevent the patient from eating. The epithelium may become denuded and the raw area covered by a fibrinous film as in the case of radium reactions. Healing is usually rapid after the withdrawal of the radiations, but localised overdosage may give rise to areas of deep ulceration closely resembling those produced by interstitial radium.

The discomforts of intensive irradiation of the mouth and throat are intensified by two additional factors, namely, damage to the parotid salivary glands leading to dry mouth, and loss of the sense of taste. The secretory cells of the parotid glands are very sensitive to the radiations, and dryness of the mouth may follow quite moderate doses. After intensive dosage it may be permanent. The mode of production of the loss of the sense of taste is not clear. It occurs even when the nasal mucosa has been carefully protected from radiations.

Intestine. The effect of X-rays on the intestine has been studied by Régaud, Nogier and Lacassagne. These authors experimented on dogs, whose gastro-intestinal mucous membrane is similar to that of man. They found that serious changes occurred in the walls of the intestine very soon after irradiation With even moderately large doses (10 H. through 2 mm. al.) the lesions produced were rapidly fatal. The degenerative changes were seen principally to affect the villi of the small intestine, the crypts of Lieberkuhn, the intestinal lymphoid elements, and the glands of the fundus of the stomach The covering epithelium of the villi was damaged and in places detached, and the stroma was also shrunken. The crypts of Lieberkuhn were markedly affected, and after large doses completely destroyed. Moderate doses caused a shrinking of the glands, due to degeneration of the cylindrical lining epithelium. The lymphatic elements were damaged, but to a much lesser degree than one would expect in view of the high degree of sensitivity of the splenic and other lymphoid tissues. In the stomach the oxyntic cells of the fundus glands were found to be shrivelled and degenerated. In one case, the dog was given a meal of fowl bones twelve days after the irradiation. This animal died two days after the meal. Two control (unirradiated) animals who had partaken of the same meal remained well. Post-mortem examination revealed early peritonitis, but no intestinal lesion. In another case, perforation of the colon and peritonitis followed the accidental ingestion of hard food after the irradiation.

The importance of the clinical application of these observations scarcely needs to be laboured.

Radiogenic Enteritis is the term applied to a more or less severe inflammation of the bowel following a therapeutic irradiation. It usually affects the rectum, and it is almost invariably the result of a concentrating cross-fire irradiation of the pelvis.

Symptoms of the mild form are characterised by general malaise, abdominal pain and discomfort, with diarrhœa and occasional vomiting. In the severe form the symptoms are severe colicky pains, profuse diarrhœa, often with blood in the stools, frequently tenesmus, vomiting, and pyrexia. Perforation and peritonitis may occur.

EFFECTS ON THE GENITO-URINARY SYSTEM

Kidneys No obvious changes are produced in the kidneys by clinical doses of X-rays. Irradiation of the kidneys is, however, followed by a temporary rise in the albumen, chloride and urea content of the urine.

Bladder. Radiogenic cystitis may follow very heavy irradiation of the bladder and, rarely, the occurrence of hæmaturia has been described in association with it. Late necrosis has been reported as following repeated intensive irradiation of the bladder. The condition must be very rare and may be due to faulty technique.

Testes. Sterility unaccompanied by impotence may follow therapeutic exposure of the testis, but it has also frequently resulted from chronic accidental exposure. Recovery may occur in either case, even when complete azoöspermia has persisted for a long period

Ovaries. As in the case of the testis, the ovarian function can be destroyed temporarily or permanently by exposure to moderate or large doses respectively of X-rays. Sterility may follow either therapeutic or accidental exposure. Temporary sterilisation by means of X-rays has been widely practised, especially in Germany, in the treatment of various gynæcological disorders. It would appear, however, that the practice is not without danger to the children of subsequent pregnancies, and in the writer's opinion, except in the presence of malignant disease, X-ray treatment should not be applied to the ovaries below the age of 40.

EFFECTS ON THE RESPIRATORY SYSTEM

Larynx The larynx must be regarded as a radio-sensitive organ, and, except in the presence of malignant disease, should not be subjected to heavy dosage. The changes produced are of the nature of perichondritis, and actual exfoliation of cartilage may occur In mild cases apparently complete recovery may ensue. The symptoms and signs are . pyrexia, pain, aphonia, and dysphagia, more or less severe, with great œdema of the laryngeal tissues on examination. In many cases recovery is heralded by the sudden expectoration of a small quantity of pus. The mode of production of the changes is obscure. It seems clear that the cartilages themselves are not very radio-sensitive. It has been suggested that the condition is due to a primary effect on the blood-vessels, interfering with the nutritional supply to the larynx

Late perichondritis is a not uncommon after-effect of heavy irradiation of the larynx, and it may occur months, or even years, after the treatment. The recognition of this condition is of very great importance. When occurring after some months of freedom from a malignant growth it may be taken for a recurrence, and, in view of the previous satisfactory effect of the X-ray treatment, further treatment may be given. The result of further irradiation in this condition may be disastrous.

Lungs. Fibrosis of the lungs may be produced by intensive irradiation. It has been observed mainly after the treatment of breast and œsophageal growths.

Modern improvements in technique have eliminated the danger of this lung damage in the treatment of carcinoma of the breast, and its incidence after irradiation of carcinoma of the œsophagus has been greatly reduced.

EFFECTS ON NERVOUS SYSTEM, EYE, THYROID AND THYMUS GLANDS

Nervous tissue is one of the most resistant tissues in the body to radiations. Very large doses are tolerated without damage. The conductivity of sensory nerve fibres appears to be diminished for a variable period after an X-ray exposure. In this way, pain may be relieved in the irradiation of a malignant growth long before any change has been produced in the growth itself. The secretory activity of the cells of the *choroid plexuses* is reduced by irradiation, and this effect has been made use of in cases in which a temporary reduction in intra-cranial tension is required.

Eye. Conjunctivitis may be produced by intensive irradiation, and serious consequences may follow where there coexists a lesion of the fifth nerve interfering with its trophic functions. Late cataract may occur many months after intensive irradiation of cranial or naso-pharyngeal growths. The cataract is amenable to surgical treatment.

Thyroid Gland. The normal thyroid gland is resistant to X-rays, and no changes are produced with clinical doses.

Thymus Gland. The same changes have been described by some authors in this gland as are seen in lymph glands. Good effects are produced by X-rays in some cases of status lymphaticus.

THE CONSTITUTIONAL EFFECTS OF X-RAY TREATMENT

The constitutional effects of X-ray treatment vary considerably from individual to individual, even with the same X-ray dosage. In general, however, it may be said that these effects have been greatly lessened in severity in recent years. Three factors have contributed to this:

(1) The invention of self-protected tubes, which has minimised the diffusion of scattered radiations throughout the whole treatment room, thus rendering it easy to limit the radiation reaching the patient to the part which it is desired to irradiate.

(2) *The tendency to removal of the high tension generating apparatus away* from the treatment room. In this way the inhalation of the fumes of oxides of nitrogen by the patient is avoided. In the writer's opinion, many of the unpleasant phenomena associated with X-ray treatment were due to the inhalation of these fumes.

(3) The replacement of the single "massive-dose" methods by the modern "split-dose" techniques, making it possible to work up gradually to the full dosage over a period of several days.

In the treatment of non-malignant conditions, and of malignant conditions of superficial and limited extent, it is unusual for any constitutional effects to be produced at all. When, however, treatment has to be applied to deeply seated malignant lesions, the constitutional effects are definite and may be severe. As the treatment progresses, the patient complains of an increasing feeling of fatigue, often with intermittent nausea and sometimes actual vomiting. Rarely, vomiting becomes a serious feature, but in the days of the single massive-dose techniques it sometimes proved fatal.

X-ray sickness is the term applied to nausea and vomiting resulting from X-ray treatment. It may follow irradiation in any region, but is more common after irradiation of the upper abdomen. The cause of X-ray sickness is obscure, but it may be contributed to by absorption of the breakdown products of malignant growths. Some loss of weight is constant during an intensive course of X-ray treatment and this may amount to several pounds in the course of a few weeks.

Treatment of X-ray sickness is on general lines. The patient should be at rest, on a light, easily digestible diet. For the nausea, 10 minims of liquor adrenalini hydrochlor. in water, taken by the mouth, will often secure instant relief, and this may be repeated four-hourly with perfect safety. Another valuable drug is acid hydrocyan. dil. in 5 minim doses with bismuth. Liver is not recommended.

For diarrhœa occurring in the course of X-ray treatment, salol may be given in 5 grain doses, and this is usually sufficient to control it in the early stages. In more severe cases, chalk and opium may be used. Rectal irritation may be dealt with by the instillation of warm olive oil into the rectum.

CHAPTER III

The Treatment of Disease by X-rays

As might be expected from the great diversity of effects which can be produced by X-rays in living tissues, benefit may be obtained from X-ray treatment in a variety of different diseases. The mode of action of radiations differs greatly in the various conditions in which X-ray treatment may be given, but one large group can be separated in which the mode of action is believed to be similar, and the principles of treatment are on the same lines. This group comprises the malignant neoplasms of all types, and we shall deal with it first

MALIGNANT CONDITIONS

The earliest attempts at scientific treatment of malignant disease by measured doses of X-rays had their origin in Erlangen during the Great War. Apparatus was devised which was capable of producing radiations of great penetration; a biological unit surface dose was introduced, a system of depth-dosage measurement was built up, and, finally, a measured dose was prescribed to be applied to the lesion, whatever its depth.

In the Erlangen method, the object of the treatment was to deliver the whole of the requisite dosage within the space of a single day. This usually involved submitting the patient to several hours of continuous irradiation, in the course of which severe X-ray sickness was usually experienced. The method has now fallen into disrepute, but in judging it we must remember that it was the first accurate method of deep therapy and it produced results not previously obtained.

At the present time, in the treatment of malignant disease, the method employed is one or other modification of the intensive split-dose method in which the treatment is given as a series of daily doses over a period of several days up to a few weeks. The aim is to apply the maximum dose that can be tolerated by the healthy tissues without undue damage to them. It is not yet known what is the optimum time over which the treatment should be spread, nor is it known what is the optimum interval between individual doses. In the so-called " Coutard method " the treatment is applied twice daily, and extends over a varying time up to 6 weeks, and more recently up to 3 months.

Among other questions which are not yet settled is that of the intensity factor. Coutard prefers a very low intensity—2 to 3 r. per minute. On the other hand, the writer's recently introduced method for the treatment of carcinoma of the œsophagus is a high-intensity method and gives a high proportion of immediate good results, several patients being alive and able to swallow more than two years after treatment.

The object of all these variations in technique is to find the combination which will do the most damage to the cancer cell and the least to the normal tissues, and, with so many variable factors, progress must necessarily be slow. It may well be that different combinations will be required for the different types of cancer.

Turning now to a consideration of the disease itself, there are two factors which influence the response of a malignant growth to radiations, namely, the distribution of the disease in the patient, and a factor peculiar to the growth itself which is termed " radio-sensitivity."

From the point of view of distribution of the growth, the cases may conveniently be considered under the following headings: (1) Primary growth only discoverable; (2) Primary growth, with metastases in regional lymphatic glands; (3) Primary growth, with or without regional metastases, but with an apparently isolated distant secondary deposit; and (4) Cases in which the disease has become generalised.

(1) The cases in which the disease is apparently limited to the primary growth are, in general, the most favourable. In such of these as fall within the radio-sensitive groups (e g. carcinoma of the palate, carcinoma of the cervix, carcinoma of the testis), disappearance of the growth with adequate X-ray treatment may be expected in the majority of cases. It must, however, be understood that the disappearance of the growth does not necessarily mean the cure of the disease, since in a proportion of cases unsuspected secondary deposits become obvious at a later date, and in a further proportion of cases, local recurrences occur after a longer or shorter time, even after a period of years of freedom.

(2) In the cases in which regional lymph glands are involved, the prognosis is poor, and especially is this true when cervical glands are involved secondarily to growths in the mouth and throat. Thus a carcinoma of the naso-pharynx without glandular involvement is a favourable growth for X-ray treatment, and offers a real prospect of cure But when cervical glands have become involved, the prognosis is materially worse, although a chance of eradication of the growth still exists. Usually, however, when cervical glands have become extensively involved, secondarily to a growth in the mouth or throat, X-rays can offer hope of palliation only, and not of cure.

(3) The presence of remote secondary deposits is, in general, a contra-indication to X-ray treatment, since experience shows that such secondary deposits are practically never isolated, even although they may appear to be so. There are, however, certain important exceptions to this rule. Most important among these are the isolated secondary deposits in bone which result from carcinoma of the breast and which frequently occur in patients who appear otherwise to be in excellent general condition Such deposits, if allowed to grow unchecked, may entail great suffering Pathological fractures may result in the patient being compelled to spend the remainder of her life, perhaps months or even a year or two, bed-ridden, and paraplegia may result from such deposits in the spine. Fortunately these bone deposits respond well to X-ray treatment. The growth is destroyed and bone re-forms, so that the patient may retain a useful limb, and paraplegia may be warded off, or even relieved when it has already occurred. It is not uncommon for patients to live useful lives for two, three, or even more, years, after secondary deposits in bone have been treated in this way. Another notable exception to the rule that remote secondary deposits contra-indicate X ray treatment is in the case of testicular growths. Indeed, few testicular growths are too advanced to derive some benefit from X-ray treatment, and many patients have lived useful lives for many years after X-ray treatment of massive secondary deposits in the lumbar region arising from such growths.

(4) A malignant growth with generalised secondary deposits offers so little prospect of benefit from X-ray therapy that it is rarely justifiable to make the attempt to apply it. It is not uncommon to be presented with a patient whose general condition is apparently good, and yet who, on examination, is found to have multiple secondary deposits. In such a case, the temptation "to do something" is great. It is, however, just in these cases that ill-advised attempts at X-ray treatment do most harm, for the reduction in the general condition brought about by the treatment may start the patient on the downward path, so that he rightly dates the beginning of his break-up from the beginning of his X-ray treatment. The only exceptions to the rule that generalised malignant disease is a contra-indication to X-ray treatment are the cases in which urgent pressure symptoms can be referred to a particular growth deposit. In such cases it is justifiable to attempt to relieve symptoms by irradiating the deposit responsible, and especially is this the case if the disease is of a type which is known to be radio-sensitive.

Definition of Radio-sensitivity.

When a tumour is said to be "radio-sensitive," it is meant that it can be made to disappear by a dose of radiation that produces little or no damaging effect upon the normal tissues, local or remote. Some growths are highly radio-sensitive and can be made to disappear by a dose of X-rays which is well within the limits of tolerance of the normal tissues. Among these are the lymphosarcomata, the *seminomata of the testis, and certain brain tumours (medulloblastomata). Although such growths almost invariably respond well to X-ray treatment, the frequency of secondary deposits renders the prognosis bad, in spite of the radio-sensitive nature of the growth. However, these growths, when once successfully treated by X-rays, do not tend to recur locally, and if the patient has been fortunate enough to escape the formation of* secondary deposits there is a chance that a permanent cure may be obtained. The writer has several cases of lymphosarcoma that are well and at work after periods of several years.

The growths for which the destructive dose is somewhat greater but still falls within the limits of tolerance of the healthy tissues may be termed "moderately radio-sensitive." Perhaps the majority of malignant growths belong to this group. They are incomparably more difficult to deal with by X-rays than the previous group, because the margin of safety is small, and the greatest accuracy, both in equipment and technique, is therefore demanded, coupled with experienced judgment in the interpretation of radiation effects. Every malignant growth requires its certain minimum dose of radiations to produce any damaging effects upon it at all, and the hasty abandonment of a course of treatment once embarked upon before this dose has been given will leave the patient in worse condition than if no treatment had been given at all. On the other hand, failure to recognise the danger signals, and persistence in a course of treatment in spite of them, may lead to disaster.

Among the radio-resistant growths (e.g. carcinoma of the stomach or rectum, and fibro-sarcoma) are classified those in which the margin of vulnerability between the growth and the normal tissues is so small that it can scarcely be said to exist. These growths offer little or no prospect of benefit from X-ray treatment at present, although it is hoped that they also will eventually yield to improvement in technique.

PROGNOSIS WITH X-RAY TREATMENT IN MALIGNANT DISEASE

Carcinoma of the Skin is a radio-sensitive growth and gives excellent and permanent results with high-voltage X-ray treatment provided that bone has not become involved. If bone is involved, however, the outlook is bad unless the diseased area can be cleanly removed surgically. Operation can often be facilitated by previous X-ray treatment, and it is astonishing how large, foul, fungating growths will melt away, leaving only the portion which is attached to bone. If, however, the *whole* of the ulcerated area cannot be made to heal within a reasonable time, recurrence will inevitably make its appearance. These remarks apply equally to rodent ulcer and to squamous-celled epithelioma.

Mouth and Throat The most radio-sensitive growths in these regions are those originating respectively in the palate and the naso-pharynx. These growths yield to X-ray treatment in a high proportion of cases, and even when cervical glands are involved provide a proportion of cases with five-year freedom from recurrence. It is a curious fact that these observations apply to all growths in these two sites, whatever their histological characters, thus illustrating what has previously been stated, that the sensitivity of a growth frequently depends more on its site of origin than upon its histological structure. Except in very small and localised lesions, all malignant growths of the palate and post-nasal space should be treated in the first place by high voltage X-ray therapy in preference to interstitial radium.

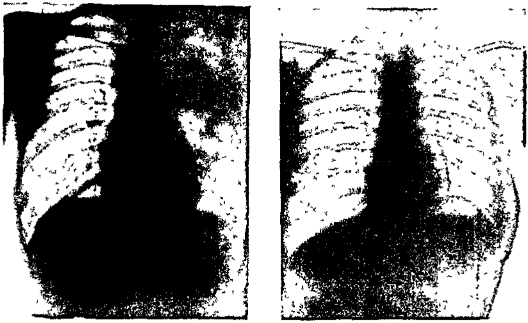
In contrast to the palatal and naso-pharyngeal growths, carcinoma of the tongue and vallecula, and of the tonsil, and extrinsic carcinoma of the larynx tend to be resistant to X-ray treatment and should be treated by radium wherever practicable. Carcinomata of the lower pharyngeal wall and also of the post-cricoid region vary in their sensitivity and give a small proportion of five-year results.

Respiratory System Intrinsic carcinoma of the larynx tends to be a radio-sensitive growth It gives rise to metastases in glands only late in its history, and is therefore particularly suitable for local treatment by the radium fenestration method. It is not yet possible to say how the results of X-ray treatment compare with the results of radium applied by this method, but the proportion of successes is comparatively high.

Bronchial carcinomata, the so-called carcinomata of the lung, give, on the whole, bad results, although occasional successes are encountered (fig. 2926). The results in carcinoma of the lung are in contrast to those obtained in growths arising primarily in the mediastinum, in which dramatic results are often produced A fair proportion of patients with mediastinal growths survive for several years, although sooner or later recurrence is the rule.

Alimentary Tract. Reference has already been made to the writer's treatment of carcinoma of the œsophagus. This method was first introduced in April 1933, and although it is as yet too early to judge of its ultimate value it may be said that in a high proportion of cases normal or almost normal swallowing may be restored Several patients are alive and well two years and upwards after the treatment (fig. 2927). In a proportion of cases fibrous strictures occur at a later stage (see fig 2928).

As affecting the remainder of the alimentary tract, malignant disease offers but a poor field for X-ray treatment. Carcinoma of the stomach and carcinoma



(a) Before treatment. (b) Three years after treatment.

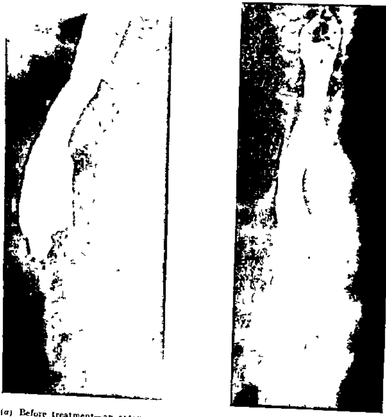
Fig. 2926.—Intra-thoracic malignant neoplasm (bronchial carcinoma) treated by X rays.

(a) Before treatment. (b) After treatment.

Fig. 2927.—Carcinoma of the œsophagus treated by X rays (Levitt's method).

of the rectum are both radio-resistant growths, and carcinoma of the colon is best treated surgically. It must, however, be mentioned that superficial secondary deposits from carcinoma of the rectum often yield to X-ray treatment.

Genito-Urinary System. Renal tumours are often radio-sensitive and quite large masses may disappear following X-ray treatment. Recurrence may occur after a few months, but occasionally the patient may remain well for several years. A combination of irradiation and surgery, whenever possible, should offer a chance of more permanent success. The so-called Wilms tumours occurring in children



(*a*) Before treatment—an extensive carcinoma.

(*b*) Present condition. Patient alive and well, two years after treatment.

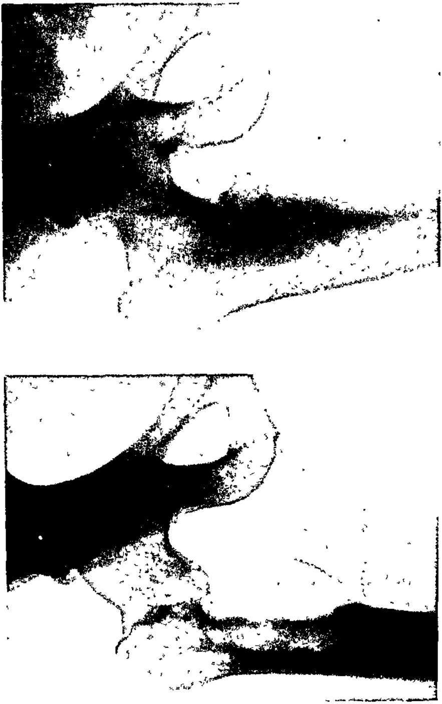
Fig 2928.—Fibrous stricture following X ray treatment of carcinoma of the œsophagus (Levitt's method)

are often radio-sensitive, and inoperable growths of this type may be rendered amenable to operation by means of X ray treatment. Children tolerate X-ray treatment well, but a most careful watch on the blood count is necessary if the treatment is to be carried out without risk

Carcinoma of the prostate may be classed as a moderately radio-sensitive growth In a series of fifteen cases of this disease, uncomplicated by palpable enlarged glands or secondary deposits, all symptoms and signs disappeared following X-ray treatment in seven. In all except two of these cases the disease recurred after an interval of freedom which averaged only ten months. A shorter remission is usually obtained from a second course of treatment. It is hoped

in the future that by applying a second course of treatment before recurrence is actually observed, improvement in the results may be effected.

In carcinoma of the bladder, considerable palliation may often be achieved by X-ray treatment. Hæmorrhage may be relieved, with consequent relief of the



(b) One year after treatment The growth has become replaced by a solid mass of new bone

(a) Before treatment.

Fig. 2923.—Extensive secondary deposit in neck of femur, treated by X-rays

pain due to the passage of clots. Little more than palliation, however, can be hoped for in this disease.

Testicular growths are among the most radio-sensitive met with, especially the so-called seminomata of the testis. These growths melt away with quite small

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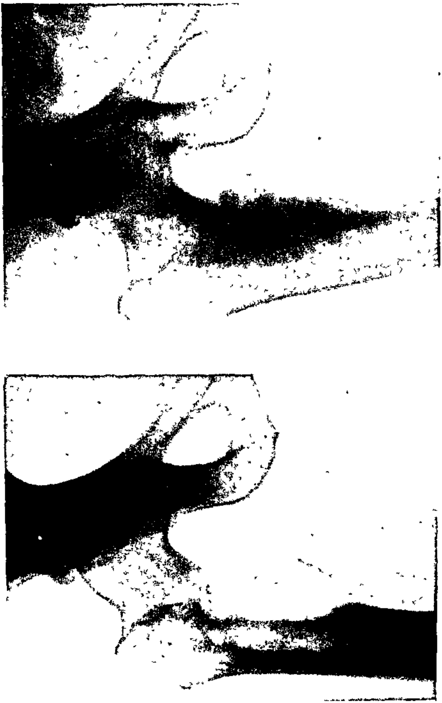

(a) Before treatment. (b) One year after treatment. The growth has become replaced by a solid mass of new bone.

Fig 2020.—Extensive secondary deposit in neck of femur, treated by X-rays.

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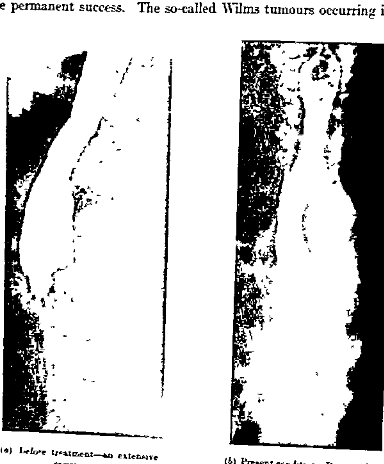

(a) Before treatment—an extensive carcinoma.

(b) Present condition. Patient alive and well, two years after treatment.

Fig. 2293.—Fibrous stricture following X-ray treatment of carcinoma of the œsophagus (Levitt's method).

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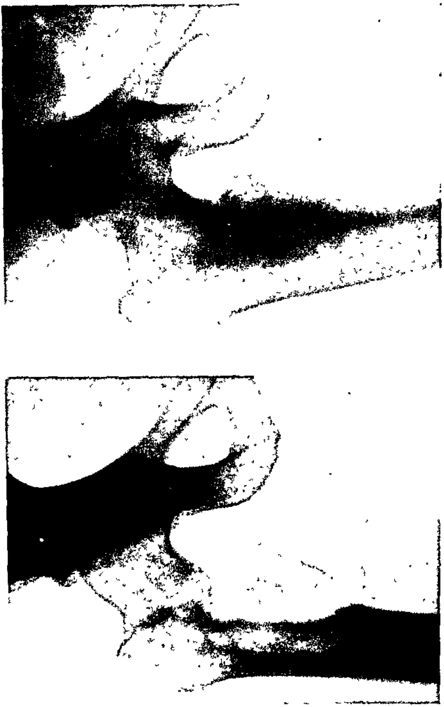

(a) Before treatment.

(b) One year after treatment. The growth has become replaced by a solid mass of new bone.

Fig. 2929.—Extensive secondary deposit in neck of femur, treated by X-rays.

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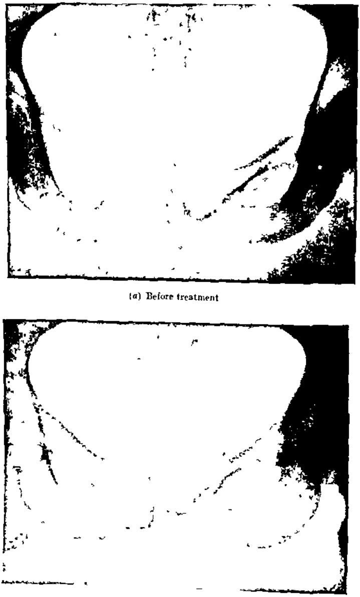
Testicular growths are among the most radio-sensitive met with, especially the so-called seminomata of the testis. These growths melt away with quite small

doses, and even abdominal deposits may often be got rid of for periods of years. Indeed, it is not too much to say that there are few testicular growths that are too advanced to offer a prospect of benefit by X-ray treatment.

Carcinoma of the Breast. Although it is difficult to find conclusive evidence, it is probable that the results of X-ray treatment alone are inferior to those of surgery in the treatment of operable carcinoma of the breast. On the other hand, it is beyond doubt that in a large proportion of cases carcinoma of the breast is a radio-sensitive growth, and in view of the fact that operable curability and radio-



(*a*) Before treatment

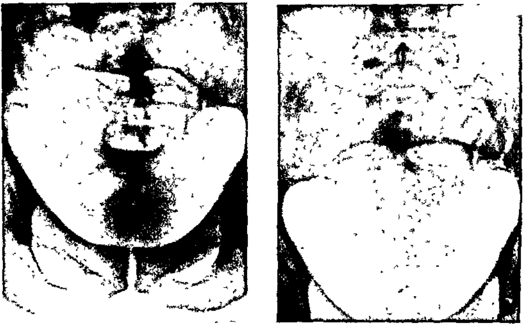
(*b*) Present condition Patient alive and at work, eighteen months after treatment

Fig 2930.—Secondary deposit in pubic bone (from a carcinoma of the breast) treated by X-rays.

sensitivity depend respectively on such very different factors it seems but reasonable to combine the two methods of treatment in the hope that at least a partial summation of the results may be obtained.

For this purpose, the operation may be preceded or followed by irradiation, or both pre- and post-operative irradiation may be given. The latter is probably the ideal method and is that practised in Stockholm.

As regards inoperable carcinoma of the breast, great improvement may be effected by X-ray treatment and frequently the growth may be rendered operable. Occasionally, very extensive breast growths with axillary and even supra-clavicular gland involvement may disappear completely after X-ray treatment, but this is



(a) Before treatment—showing extensive destruction of bone

(b) Present condition—showing disappearance of growth and regeneration of bone. Patient well and at work over three years after treatment.

Fig. 2931.—CHONDROSARCOMA OF SACRUM.

exceptional and a more usual result is reduction in size of the growth which may then remain apparently inactive for a longer or shorter period before recurrence or secondary deposits appear.

X-ray treatment is unfortunately of no value in *preventing* the occurrence of secondary deposits in carcinoma of the breast. Its value, however, in the treatment of isolated bone deposits has already been referred to (see figs. 2929 and 2930).

Cerebral Tumours. Of the malignant neoplasms that occur in the brain, only the medulloblastomata are highly radio-sensitive. These growths are most commonly found in children, and usually affect the cerebellum. They rapidly respond to X-ray treatment, but it is important in these cases that the treatment of the primary growth should be followed by irradiation of the whole length of the spinal canal; if this is not done, deposits of the growth almost inevitably make their appearance at different levels in the spine.

Spongioblastomata are moderately radio-sensitive growths, while the astrocytomata tend to be radio-resistant.

Of the pituitary tumours the eosinophil adenomata give the best results, while the chromophobe adenomata are, on the whole, resistant. Malignant pituitary tumours are often radio-sensitive.

Sarcoma of Bone. A certain proportion of cases of bone sarcoma responds to X-ray treatment in a most dramatic fashion, and in a few instances the patient has survived without recurrence for many years (see fig. 2931). Unfortunately, however, whether the primary growth responds or not, the end in the majority of cases is the same, and the patient dies of secondary deposits. In many cases X-rays are of great palliative value, inasmuch as they arrest the growth of the primary lesion, and so avert ulceration and much suffering. In cases in which the sarcoma affects a long bone, it is unwise to delay amputation in favour of X-ray treatment, since so long as the primary growth is allowed to remain it must be regarded as a menace to the patient's life from the production of secondary deposits. There is, however, evidence that a combination of X-ray therapy and surgery offers some hope of eradication of the disease. Of 32 cases of bone sarcoma treated by X-rays and surgery, and by X-rays alone, at St. Bartholomew's Hospital from 1931 to 1934, eight were well and without evidence of the disease in May 1935.

NON-MALIGNANT DISEASES

The non-malignant conditions which may be treated by X-rays can be classified as follows:

(1) Various diseases of the skin, including keloid and contracted scars.

(2) Certain acute inflammatory conditions—boils and erysipelas.

(3) Certain chronic inflammatory conditions, simple and tuberculous. This group may be further sub-divided as follows: (*a*) Chronic enlargement of lymphatic glands, usually tuberculous: (*b*) Tuberculosis of the larynx; (*c*) Tuberculous peritonitis; (*d*) Certain forms of chronic arthritis; (*e*) The earlier stages of simple enlargement of the prostate, (*f*) Septic and tuberculous sinuses; and (*g*) Actinomycosis

(4) Chronic leukæmias.

(5) Lymphadenoma

(6) Hyperthyroidism.

(7) Certain gynæcological conditions.

(8) Chronic mastitis.

(9) Parotid cysts and fistulæ

(10) Certain neuralgias: (*a*) Post herpetic; (*b*) Trigeminal.

Diseases of the Skin The treatment of the non-malignant diseases of the skin by X-rays, with the exception of keloid scars, usually falls to the lot of the dermatologist, and it will not be further discussed here.

Keloid scars respond well to X-ray treatment. The best results are obtained from the bright red exuberant type of keloid. X-rays are definitely superior to radium, but the dosage must be correct and the technique accurate. Usually two or three exposures are sufficient at intervals of several weeks. The final result is a flat smooth white scar, but it must be remembered that the superficial extent of the scar is the same as that of the preceding keloid, and therefore if a linear scar is desired the X-ray treatment is best combined with excision. X-rays are a valuable prophylactic against keloid formation in operation scars, one exposure being given before and one after the operation.

Acute Inflammatory Conditions. Remarkable results are often produced by the application of tiny doses of X-rays in the treatment of boils and carbuncles. In many cases the application of a single dose will effect the rapid resolution of a boil or a crop of boils X ray treatment is of special value in cases of recurring furunculosis. Good results have also been reported in the treatment of erysipelas.

Enlarged Glands The treatment of glandular enlargements, usually of tuberculous origin, will vary with the condition of the glands Long standing enlargements which show no evidence of breaking down are best treated by small weekly doses of moderately hard rays for six to eight weeks, and the results are excellent Larger doses may lead to a quicker result, and may save the patient a certain number of exposures but they involve the risk that the glands may break down.

Glands which are more acute in character, or show a tendency to breaking down, have to be given still smaller doses at weekly or slightly shorter intervals over a longer period An exceedingly important point is that whenever fluctuation is detected the glands should be aspirated under the most stringent aseptic conditions They should never be allowed to discharge spontaneously if this can possibly be avoided, and it is frequently found that a mass which has had to be aspirated on several occasions may disappear without a sinus or indeed without a trace of its presence being left on the surface (see also page 1119)

In this, as in other chronic inflammatory conditions the chronicity of the process is due to, or at any rate contributed to by, the packing of the tissue spaces with the lymphocytes, which are characteristic of chronic inflammation Now the lymphocytes are among the most sensitive cells in the body to radiations, in fact, a blood count on any patient who has had intensive irradiation invariably shows a leucopenia which may persist for weeks It is therefore reasonable to suppose that the rays act by destroying many of the cells which pack the interstices of the gland, thus inducing an increased circulation through the gland, and an inflammatory reaction depending in intensity upon the dosage applied In fact, therefore, what we do by our X ray treatment is to induce and keep up an inflammatory reaction of a grade which can be controlled by the dosage, so that the tuberculous or other infective process is dealt with by the tissues much more energetically than it otherwise would be The after effects of the treatment are negligible Tuberculosis of the larynx and other tuberculous conditions are treated on the same lines

Chronic Arthritis X rays are frequently recommended for the treatment of chronic arthritis Except in the case of spondylitis, where remarkable results are occasionally seen, the writer has personally had little success in the treatment of these conditions

Enlarged Prostate The treatment of prostatic hypertrophy by X-rays is only advised in the stage before the urine has become infected, and even then only in the presence of some contra-indication to operation Only when comparatively large doses are applied are successes obtained, and such doses are associated with the same unpleasant temporary effects as are seen in the treatment of malignant disease

Actinomycosis This condition sometimes yields to X-ray treatment There are two methods of application In the first method, which is the more rapid in its result and probably gives the higher proportion of successes, a single large dose

is applied to the affected region. This is followed by severe local and constitutional reactions, after which healing usually occurs. In the second method, small doses are applied at intervals of several days, and the treatment may have to be kept up for several months before a result is obtained. Improvement is usually manifest after three or four doses, and no unpleasant reactions follow the treatment.

Leukæmia. The use of X-rays in the treatment of this disease, or rather group of diseases, is practically confined to the more chronic types. Except for palliative purposes in the relief of urgent pressure symptoms, e.g. greatly enlarged cervical glands pressing on the trachea, X-rays have no place in the treatment of acute leukæmia.

Chronic leukæmia cannot be cured by X-ray treatment, although marked temporary improvement can be obtained. The patient after a course of treatment improves in general health; he loses his dyspnœa; his ankles cease to swell; the spleen, which may be enormous to begin with, recedes so that it can no longer be felt: the red blood-corpuscles increase to normal, and with them the hæmoglobin; and, the most striking of all, the white cells are reduced to normal total numbers, and in myeloid leukæmia usually to approximately normal proportions. In recent years we have learnt to guard against the dangers which were formerly associated with the treatment of this disease, and with greater exactitude of dosage our treatment is under more exact control. We can, therefore, as a result of our irradiation, and without undue danger, bring the patient to a state closely approaching normality He feels better and is able to go about his work more efficiently for the greater part of the span of life that remains to him. On the other hand, it is probable that on the whole life is not very greatly prolonged; but although the duration of life is not greatly increased its quality is much improved by the X-ray treatment. Thus the patient who, without X-rays, would be doomed to spend the greater part of the remaining months or years of his life in his bed is, as a result of X-ray treatment, restored to fair comfort and ability to work until quite shortly before the end

The X-ray treatment of leukæmia is best applied as a short semi-intensive course, with the object of reducing the white count to from 8000 to 10,000 per c.mm. It is found that it is only when the white cells are reduced to this level that the longest remissions are secured. On the other hand, experience and judgment are required if the leucocyte count is to be brought as low as this without undue danger. It should be remembered also that the count continues to fall for two or three weeks after the X-ray treatment has been completed, and therefore treatment is usually stopped when the white count has fallen to 15,000 or 20,000.

Lymphadenoma Here again we have to deal with a disease which, although incurable, is greatly relieved by X-ray treatment. Not only can local swellings be made to disappear wherever they arise, but the peculiar toxæmia associated with the disease can be held in check for a longer or shorter time. Ultimately, however, extensive abdominal and thoracic deposits appear which herald the end. The outlook with abdominal and thoracic deposits is necessarily grave, but recently a form of " X-ray bath " treatment has been developed at St. Bartholomew's Hospital which has enabled us to secure quite long further remissions even in these cases.

The average duration of lymphadenoma with X-ray treatment is a few years after coming under observation, but it is not uncommon for cases to go on for eight, ten, or even twelve years.

Hyperthyroidism. The value of X-rays in the treatment of hyperthyroidism has now been placed beyond any reasonable doubt, and a high percentage of successful results is obtained in suitable cases. The cases that do best are those which occur in association with the changes of puberty and the menopause, although good results are often obtained at other ages also. It should be noted that the term "successful" must not be held to imply a perfect cure. The pulse-rate is restored to normal, as also the weight, and the patient becomes less nervous and excitable. The basal metabolic rate also becomes approximately normal. The exophthalmos, however, rarely completely disappears and is often only moderately improved.

X-rays versus Operation in Hyperthyroidism. In comparing the relative merits of X-rays and operation, the immediate and obvious disadvantage of the radiation treatment is the length of time required to produce a result. Improvement only begins two or three weeks after the treatment has been instituted, and takes several months to become complete. If the patient is a wage-earner, it will often be considered advisable to operate rather than to await the results of X-ray therapy, except in the case of the hyperthyroidism of puberty, where the results are so good as to render a trial of X-ray therapy desirable in the majority of cases. It is often stated as one of the objections to X-ray treatment that late effects on the skin in the form of telangiectases and pigmentation are liable to be produced. While this was true in the days when soft rays were used in the treatment, it certainly is not true of modern treatment, in which the use of fairly penetrating rays permits of the requisite dosage to the deeper parts of the gland with comparatively low skin dosage.

The course of hyperthyroidism under treatment by X-rays is as follows: First, the weight increases, and some improvement may be noted in this respect after a single dose. Next, the pulse-rate begins to fall and, in favourable cases, continues to fall steadily throughout the treatment. Diminution in the tremor and nervousness soon follows, and improvement in the eye signs occurs last of all.

Treatment is applied weekly for about two months, and a second course may be required after an interval of two or three months. Dosage is low, about a quarter of a U.S.D. on each occasion.

Gynæcological Conditions. These are most easily discussed if we classify uterine hæmorrhage due to other causes than malignant disease, with special reference to the mode of treatment under consideration.

We may first sub-divide the causes of uterine hæmorrhage into functional and organic. *Functional* hæmorrhage occurs at two epochs—puberty and the menopause. Except in cases of such gravity that life is threatened, X-ray treatment should not be employed in the hæmorrhage of puberty. However, in cases of sufficient gravity, X-ray treatment is always to be preferred to hysterectomy, since the sterility induced by X-rays in such cases is only temporary, persisting for a few years. Moderate doses only are required, and the reaction induced by the treatment is not severe.

In functional menopausal hæmorrhage, X-ray treatment is the treatment of choice, the results are swift and certain, and the after-effects transient and of little account.

As regards the hæmorrhages of *organic* origin, these may be due to a variety of causes, although the greater number are associated with the presence of fibroids.

Tuberculosis and other chronic inflammatory conditions of the adnexa may also be responsible. Space does not permit of a consideration of these conditions in detail, but it is possible to make certain generalisations which apply to all of them.

In the first place, since in most cases the treatment involves sterilising the patient, X-rays should not be employed in the treatment of non-malignant pelvic disease in the female in the child-bearing age. There are only a very few exceptions to this rule. Only when the disease is so extensive as to preclude any possibility of a future pregnancy or when it is progressive (for example, advanced pelvic tuberculosis) so as to threaten life, or when no other treatment is possible, is it justifiable to apply X ray treatment in women under 40 years of age. Between that age and the menopause the contra-indications may be somewhat relaxed, but under the age of 45 such treatment should not be applied without careful consideration.

Although temporary sterilisation, with subsequent complete recovery of function, can be carried out in patients under 40, and is often recommended in the treatment of various conditions, it is not, in the writer's opinion, justifiable, except in the presence of one or other of the indications referred to. Mental changes may be serious after sterilisation of young women, but in older women they differ in no way from those of the normal menopause.

Chronic Mastitis. In a considerable proportion, perhaps half, of the cases of chronic mastitis, complete, or almost complete, relief of symptoms can be obtained from X-ray treatment. Although the condition is usually bilateral, it is commonly more advanced on one side, and it is a good plan to begin by applying the X-ray treatment to that side In this, improvement can be more accurately estimated, and if a successful result is obtained, the opposite side can then be treated. Symptomatic relief in the successful cases is striking and often dramatic, and although the objective improvement may lag somewhat behind the symptomatic relief, the breast is often eventually restored to an apparently normal condition. A note of warning may here be sounded As has been previously indicated, the X-ray treatment of malignant and non-malignant conditions is carried out on entirely different lines, and the treatment for chronic mastitis would be useless in a case of carcinoma It is quite wrong, therefore, to refer a case for X-ray treatment with a diagnosis of chronic mastitis, with the mental reservation that even if the breast contains early carcinoma the X-rays will do some good.

The X-ray treatment of chronic mastitis is applied in the form of weekly doses of moderately hard rays Moderately hard rays are used in order to secure the requisite dosage in the depths of the gland while avoiding heavy irradiation of the skin. No skin changes are produced, and should intensive X-ray or radium treatment be subsequently required for carcinoma, its effective execution will not be prejudiced. From six to twelve weekly doses may be required for each breast.

Parotid Cysts and Fistulæ. It is not generally known that complete sterilisation of the secreting tissue of the parotid gland may be effected with ease and certainty by accurately measured doses of X-rays. In this way relief may be obtained in this uncommon, though very distressing, group of conditions.

Certain Neuralgias. Great relief is quickly obtained in a proportion of cases of post-herpetic neuralgia by the application of X-rays to the posterior nerve-roots. In the same way, relief may be obtained in *tic douloureux* by irradiation of the Gasserian ganglion. The mode of action is not known.

PART XXXVIII

SOME ASPECTS OF GENERAL SURGERY

by

HAROLD DODD

SOME ASPECTS OF GENERAL SURGERY

CHAPTER I

Shock

There is an aphorism that "shock is hæmorrhage and hæmorrhage is shock"; like many such phrases, it is a half-truth, but it has a practical value—i.e. that shock is avoided or retarded by minimising hæmorrhage. Shock describes the condition of a patient who is suffering from a serious depression of the vital activities of the body after an injury (used in the widest sense); it may terminate fatally. In varying degrees it develops after all insults—physical, bacterial or mental.

For years, two forms of shock have been described—primary and secondary, a classification of clinical value, but one which suggests—incorrectly, for shock appears to be a continuous phenomenon—that they are two separate processes. Primary shock is popularly referred to as a "faint." It is of rapid onset, and the patient loses or almost loses consciousness. As a rule, recovery soon follows in response to treatment. Secondary shock is a more serious condition. It is characterised by a complete and continuous collapse which develops gradually, or occasionally suddenly, one to twelve hours after an injury or an operation.

Primary shock is believed to result from a sudden cerebral anæmia. It is associated with: (1) severe emotional upsets—e.g. the sight of blood, an accident, or the receipt of unpleasant news; (2) slight but painful mishaps, such as a cut finger or the prick of a hypodermic needle; (3) severe injuries; (4) the fearful anticipation of an operation, major or minor; (5) the initial skin incision of an operation. (The opening of the peritoneum or of the dura mater sometimes provokes a temporary collapse or, rarely, even death.)

The *signs and symptoms* of *primary shock* are sudden loss of consciousness, and extreme pallor with slightly cyanosed greyness of the nose and ears. The mind is inactive, lapsing into unconsciousness, which is perhaps interspersed with periods of apathy or emotionalism. The pulse is small or impalpable. The blood-pressure is scarcely recordable, occasionally for as long as an hour. Respiration may be so quiet that the movements are imperceptible; it may be Cheyne-Stokes in character, or may consist of prolonged sighs—three or four to the minute. The sphincters sometimes relax, with the passage of urine and fæces. The voluntary muscles are completely flaccid, and purposeful movements are in abeyance. This state lasts for a few seconds or even for several minutes. Recovery follows gradually on the application of simple measures such as loosening tight clothing, bathing the face and neck with cold water, introducing fresh air, bringing ammonia or carbon dioxide to the nostrils, laying the patient down, or pressing the head between the knees. The effects of the condition are transient and seldom immediately fatal. When consciousness returns, a drink (hot or cold) or a drachm of sal volatile furthers recovery.

The marked fall in blood-pressure is probably due to sudden inhibition of the

vasomotor centre from a stimulus to the central nervous system, and is usually temporary. Although the pressure may be so low as to be unrecordable, patients usually recover. Occasionally, however, the diminution of blood-pressure persists and death occurs. There is no reduction in blood volume as in secondary shock, so that no ill-effects develop so long as the circulation to the vital centres of the brain is maintained.

The connecting link between primary and secondary shock may be the cumulative effect of the continued low blood-pressure, prolonged by the nature, the extent, and the effects of the injury. The oxygen requirements of the tissue cells in the average patient can be satisfied by a systolic blood-pressure of 80 mm. Hg., but if the tension falls to and remains at 70 mm. or less for some time, then cellular anoxæmia occurs, and, aggravated by other factors, the state of secondary shock develops.

Secondary shock particularly follows three types of injuries: (1) Those associated with hæmorrhage and muscle trauma; (2) Burns, especially of the second and third degrees; and (3) Abdominal catastrophies, chiefly those interfering with the blood supply of the bowel.

Loss of blood in an injured or sick person rapidly brings on shock. If an injured animal is bled it quickly dies after losing a volume of blood which scarcely affects a similar healthy animal. Large contusing injuries involving muscles, skin, main blood-vessels and joints, and gross trauma to the chest, abdomen, neck, kidney area, testicles, or spinal column and cord are associated with marked shock. Although considerable hæmorrhage may be a factor, shock can still develop even when it is slight or apparently absent—for example, patients with burns or simple fracture of the femur frequently die of shock. In extensive superficial burns or scalds the multiple and continued painful stimuli to the nervous system probably play a large part, and the loss of large quantities of serum from the affected area has a detrimental effect. The absorption of burnt tissue contributes to the persistence of the shock. A perforated ulcer or wound of the stomach, duodenum or bowel, and the rupture of an abscess into the peritoneal cavity are shock-producing accidents. Interference with the blood supply to the intestines, as in the case of a strangulated loop of bowel or acute intestinal obstruction, is, unless promptly relieved, complicated by a serious degree of shock which responds to treatment tardily or not at all.

All surgical procedures are associated with a certain degree of shock, but some cause more than others. In this category are intra-cranial and intra-thoracic injuries and operations, handling of the intestines and pulling on the mesentery, manipulation of the common bile-duct or of the urinary bladder neck, wide exposures of the shaft of the femur (especially in children), high amputations through the thigh or hip-joint, and surgery about the anus.

The dyspnœa and rigidity usual during light anæsthesia are often followed by a stormy convalescence, and if marked during a laparotomy the so-called "post-operative chest" of abdominal distension can be predicted almost with certainty. A further result of cyanosis and muscle rigidity is a rise of blood-pressure and an increase in bleeding, which occupies valuable time in swabbing, and in clipping and tying off vessels. Furthermore, strong retraction is necessary, and the operation is difficult and prolonged.

There are several contributory causes of secondary shock. Continued pain

stimulates and exhausts the adrenal and sympathetic nervous systems. It is present in varying amounts in all injuries, but is especially severe in burns of the second and third degrees. Loss of body fluids from starvation, thirst, profuse sweating, vomiting or diarrhœa, ooze of serum from second degree burns and hæmorrhage are important. Lack of warmth is another factor. Mental stress, fright, anxiety, physical fatigue, etc., are found particularly in wounded soldiers, in the victims of explosions, and in those who have met with road or train accidents. Debilitation by previous illness, such as typhoid fever, pneumonia, chronic gastric ulcer, malignant disease and anæmia, renders patients readily susceptible to shock.

Signs and Symptoms of Secondary Shock. Here the skin, especially that of the fingers, toes, ears and nose is cold, shrunken, pale or ashen grey, or cyanotic. It is moist from profuse sweating with consequent loss of heat and fluid. The respirations are slow and shallow and may be imperceptible. The breath feels cold to the hand ; this is a valuable but serious sign, so that restorative measures must be started promptly before the power of response is lost. The pulse is variable, occasionally irregular, even impalpable ; it may be rapid, especially after muscle trauma, but sometimes it is slow perhaps under 70, as in the early stages of perforation of the stomach or bowel. The heart sounds are soft. The low blood-pressure is the most significant measurable factor of secondary shock. A systolic reading below 80 is not unusual, whilst the diastolic figure may be obtained with difficulty or perhaps not at all. The temperature is usually sub-normal, but is occasionally raised a few points, and in burns hyperpyrexia is not unusual. The locomotor system is flaccid and weak. The patient, when urged, will voluntarily, slowly and feebly move the uninjured parts, but otherwise lies quite still, occasionally moaning feebly. The victim is generally semi-conscious, but is apathetic and *indifferent to his surroundings, looks anxious, and does not talk. The volitional* processes are dull and slow. Insistent questions are answered deliberately after a pause. *Absolute immobility, both mental and physical, is the characteristic of a* patient suffering from shock. The pupils are dilated but react sluggishly to light, *and the eyes are half or fully closed. Occasionally, however, patients are restless or* even delirious, especially in gross sepsis—a state which aggravates the shock. Persistent thirst is complained of, the tongue being clean and perhaps dry. Vomiting may further deplete the body fluids. The vesical and rectal sphincters are generally closed, but may be relaxed, causing some incontinence. Urinary secretion is almost in abeyance, and sometimes there is insufficient urine to supply a specimen for examination.

Post mortem, the pallor of the heart, lungs, kidneys, intestines and omentum is striking. This is due to an intense vasoconstriction. Microscopically, the capillaries of the intestinal villi are congested and packed with corpuscles.

THEORIES OF THE PATHOLOGY OF SECONDARY SHOCK

Of the several theories formulated to explain secondary shock not one satisfactorily accounts for the conditions found in the various types of injury causing it. The essential measurable factors are a 40 to 50 per cent diminution in the *volume of circulating fluid and a systolic and diastolic blood-pressure of from* 90 mm. Hg. down to unrecordable levels.

(1) *The Fluid Loss Theory.* *In recent years, excellent work on the importance*

of the loss of fluid from the circulation after tissue injury has been done by Blalock, Holt, Macdonald, O'Shaughnessy, Slome and others. Animals were severely shocked by gross trauma to one leg; in some, death followed, whilst the others were killed afterwards. Wide symmetrical amputations of the lower limbs (including the pelvic girdle) were then performed. It was found that the injured member was heavier than its uninjured fellow by an amount equal to from 40 to 50 per cent of the estimated volume of the animals' circulating blood. The increase in weight was due to a mixture of blood and plasma extravasated into the muscles and fascial spaces. Such a leakage would account for the diminished volume of circulating blood in traumatic shock, apart from the actual loss of blood and from the immeasurable effects of the painful stimuli of the injury. This shock did not develop if the artery and vein to the limb were occluded before the trauma. Blalock further found that there are similar extravasations of fluid into the tissues after burns or considerable handling of the intestines. In second degree burns, in addition to this leakage into tissue spaces, large quantities of serum (1 to 2 pints) may ooze from the burnt surface—a factor which lowers the volume of circulating blood. It was also established that the circulatory changes in shock caused by direct hæmorrhage are identical with those following muscle trauma. The circulating blood is diluted, suggesting some reinforcement of its volume from tissue fluids. On the other hand, the capillary blood shows a concentration of red blood-corpuscles, even to stasis, which is probably explained by loss of plasma through the walls into the tissues. Holt considers that the local fluid loss can be "regarded as the initial factor of secondary hæmorrhage." Healthy patients and animals tend to recover steadily from the initial fall in blood-pressure, but the dehydration by hæmorrhage, vomiting, sweating, etc., combined with the deleterious effect of mental tension, and the continued adrenal expenditure by pain and perhaps from toxæmia tend to maintain the shock. Slome, Knight and Holt however consider the fluid loss theory insufficient to explain the collapse and death following the strangulation of loops of intestine. They regard it as a contributory but not a principal factor in such a condition.

(2) *The Toxic Theory.* The belief that shock is due to a circulating toxin was brought forward by Quénu and a Medical Research Council Committee towards the end of the Great War. Their findings were as follows: (*a*) The low blood pressure in shock is independent of the nerve supply of the limb, for it occurs both in normal animals and in those in whom the spinal cord or peripheral nerve trunks have been previously divided; (*b*) When the main artery and vein to the limb are clamped before the trauma is inflicted, shock does not appear but it quickly develops when these clamps are released; and (*c*) The injection of histamine is followed by a shock-like condition, suggesting the circulation, during shock, of a histamine-like substance formed in injured tissues. From this a provisional conclusion was made that the blood carries a toxic substance from the traumatised area, and so produces the typical signs and symptoms. Recent work has modified the above views, as it is now evident that the release of the circulation into the injured limb permits leakage from the vessels into the tissue spaces, and then shock appears. Further, Slome and O'Shaughnessy have demonstrated that shock still develops after trauma to a limb in which the main vein is occluded (*B.J.S.*, 1934-1935, Vol. 22, 589). Aird, Slome, Knight and Holt, investigating intestinal strangulation, found that toxæmia is a prominent

shock-producing element. In a severe case the toxæmia appears about an hour after the insult. A histamine-like substance in high concentration is present in the peritoneal exudate of these cases, and it is probable that by its depressor action early collapse and perhaps death is caused. In the milder forms of interference with bowel circulation, even though the strangulation has been relieved and the lost fluid replaced, the shock and collapse appear suddenly after a period of apparent well-being lasting from twelve to twenty-four hours. A substance, *euglobulin, probably formed in the intestinal wall, is present in,* and *is absorbed* from, the peritoneal cavity. Euglobulin may be related to a bacterial toxin, and has a powerful depressor action. A substance akin to it has been detected in the urine of five human cases of intestinal strangulation (Slome).

Heuer and Andrus (*Ann. Surg.*, Oct. 1934, 734) have also worked on intestinal strangulation. They produced primary and secondary shock by intravenous injections into healthy animals of aqueous extractions from a loop of strangulated bowel. The resulting clinical picture was in all respects similar to the traumatic shock which follows mechanical or thermal injury. When anæsthetised animals were given these extracts, the bowel content was considerable as they were unable to vomit, but unanæsthetised animals when injected suffered from vomiting and diarrhœa. *At post-mortem examination, both groups of animals showed extreme* congestion of the liver and splanchnic viscera. These workers formed the opinion that primary shock was due to a vasodilator mechanism, and that secondary shock was caused by the fluid lost from the circulation, the mechanism being increased permeability of the capillaries resulting from toxins circulating chiefly from the gastro-intestinal tract. *In the treatment of this type of shock they* established that the administration of salines, gum salines and blood-transfusions all failed to arrest its development, although strongly hypertonic solutions were *effective for a period*. *Adrenalin, cholesterin, vitamin C and ascorbic acid were* likewise ineffective in mitigating the shocked condition. Of the many remedies tried to prevent the onset of shock, only intravenous cortin (extract of adrenal cortex), if given with the toxic injection, was effective. In animals so treated, the average loss of circulating blood volume was 8·5 per cent as against 30·5 per cent in the controls. *When the shock from the toxic injection was already present* —i.e. the fluid loss had taken place—their experiments showed that cortin alone was not effective; blood-transfusion gave slight improvement, but cortin and intravenous saline together restored and maintained the improvement. The conclusion from this interesting work is that intravenous cortin, salines, and blood-transfusion promise improvement in established shock.

In assessing the value of the toxic theory certain contrary evidence must be borne in mind: Smith, Holt, Slome, O'Shaughnessy and others, using *sensitive apparatus, failed to detect any depressor or vasodilator substance in* the blood issuing from a traumatised limb. Again, the estimation of the histamine content of muscle indicates that there is not enough in the musculature of the whole body to produce shock-like effects, though they may contain other vasodilators which might initiate shock. But a histamine-like substance is *certainly formed in acute intestinal obstruction. Again, circulatory changes in* shock and following histamine administration are not exactly similar. In histamine shock the capillaries of the viscera are congested, and the solid organs bleed freely on section in clear contrast to the marked pallor in true shock. The dilated

especially underneath the patient, and if necessary with well-covered hot bottles. The *theatre* is maintained at about 65° to 75° F. Higher temperatures cause perspiration and loss of heat and fluid.

(3) *Choice of Anæsthetic*

Gas and oxygen with a local infiltration is probably the least shock-producing anæsthetic, open ether is the next best, and chloroform should be used only when specially indicated, e g. in cellulitis of the neck. When a spinal anæsthetic is selected, then woollen stockings are worn, and the lower extremities are bandaged from below upwards to the groin; these conserve the body heat, and to some extent prevent the blood from lying in the dilated capillaries of the muscles of the legs. Blood-pressure and pulse readings are made every five minutes, and are kept at or about normal levels by the injection of ephedrine or coramine, or the inhalation of oxygen and carbon dioxide.

(4) *Operative Measures*

(*a*) *Hæmorrhage* Loss of blood is minimised by planning the incision and the approach so as to avoid large vessels and by clipping all bleeding points. The preliminary infiltration of tissue planes with novocaine and adrenalin lessens hæmorrhage and noxious impulses. A tourniquet is applied whenever possible. (*b*) *Technique.* (i) An ample incision avoids the necessity for retraction. The tissues are divided by clean cuts of the scalpel and not by tearing. Stripping and stretching are shock-producing factors, and the blood-pressure falls whilst they are proceeding (ii) The tissues are handled gently, and in abdominal operations the intestines are prevented from eviscerating, but if this is impossible, they must always be protected by relays of hot towels. The wound is mopped lightly and economically

(5) *Post-operative Measures*

The return to bed must be expeditious. When the weather is cold, the patient very ill or aged, or the distance to the ward considerable, then a warmed bed is brought into the operating theatre.

(*a*) *Post-operative fluids.* Since the primary effect of secondary shock is the diminution of the circulating blood volume and low blood-pressure, it is rational to provide the body with fluid to replace that lost, and to keep the circulation at a safe level Fluid is given in several ways:

(i) *Blood-transfusion.* When the operation has been extensive, such as an abdomino-perineal resection of the rectum, a partial gastrectomy or a high amputation of the thigh, even though the external hæmorrhage has apparently been small, the volume of blood and fluid in the part removed is considerable, and must be replaced by an immediate blood-transfusion of 15 to 20 ounces. A prompt injection is better than a later infusion when shock is established. The continuous drip blood-transfusion promises to be of great value and is discussed on page 5415. Ernest Miles reduced his operative mortality after abdomino-perineal resection of the rectum from 20 to 12 per cent by means of immediate post-operative blood-transfusion.

(ii) *Intravenous salines and gum salines.* Intravenous salines increase the circulating fluid; twenty ounces is the usual amount. Unfortunately, saline is quickly excreted from the circulation, and the patient may return to the original depressed state. Nevertheless, the improvement following is often sufficient to

tide a patient over a crisis. Saline can be injected whilst awaiting a donor for a transfusion. Intravenous salines are administered, not quicker than one ounce every two minutes; twenty ounces is the safe dose, and an interval should elapse before proceeding with a further volume. Larger amounts introduced quickly are harmful, as they may strain an exhausted myocardium, and are not infrequently followed by a rigor. Volumes of two to three pints are occasionally advised, but they are probably detrimental, and are not so beneficial as a pint one or two hours later, or given as a continuous drip saline. The continuous drip intravenous saline, by steady reinforcement of the blood volume, overcomes the disadvantage of the rapid loss of the saline from the circulation. Striking improvements have been achieved by it. Glucose 5 to 10 per cent may also be introduced in the saline; this has a nutritive value, and its hypertonicity attracts fluid from the tissues into the blood-vessels. The injection of 6 per cent *gum saline* was advised by Bayliss towards the end of the Great War. It was based on the premise that on account of its physical nature it would not escape from the circulating blood as quickly as saline, and its effects would therefore be more lasting. Clinically, opinions differ as to its value, and the method has not been widely adopted, although, in my opinion, it should always be used, especially in burns.

(iii) *Rectal and subcutaneous salines.* These are well-proved methods for the gradual supply of fluid, ensuring one to two pints every four hours. They are probably not absorbed rapidly enough to be effective in severe shock, but are adequate in the average patient after a major operation. Glucose should never be given into the areolar tissues, as it may cause considerable necrosis. By the rectum, tap-water or saline 0·6 to 2 per cent, with or without 5 to 10 per cent glucose, is frequently prescribed.

(*b*) The continuous inhalation of *oxygen and 6 per cent carbon dioxide* will raise the blood-pressure 10 to 20 mm. Hg. It restores the oxygen-starved tissues and, when given through a mask as a gas and oxygen anaesthetic, it deepens the respirations and improves the systemic and respiratory circulations. The blood-pressure falls when it is withdrawn.

(*c*) *Drugs* are directed mainly to the support of the heart action, and to uphold and to increase the blood-pressure. When possible they are injected directly into the circulation—i.e. intravenously—rather than subcutaneously or intramuscularly, for in shock the capillary and lymphatic streams are sluggish, and a delayed response follows remedies so given. The veins in shock are usually empty, but a rubber band or the bag of a blood-pressure apparatus lightly applied to the upper arm for a short period will fill the median basilic sufficiently for an intravenous injection, the effect being apparent in thirty to sixty seconds.

(i) *Ephedrine and icoral.* Of all preparations, ephedrine stands out as a dependable pressor substance with a moderate and sustained action. Intravenous adrenalin acts violently and instantaneously, but for a few minutes only. Ephedrine (½ to 1 gr.) intravenously raises the pressure to within normal limits, and maintains it for a half to one hour. Thus regular and frequent baumanometer readings are required in assessing the patient's progress and requirements. Icoral (Bayer) is more powerful than ephedrine, and its action is continuous. Caution is necessary in its use; 1 to 2 cc. will raise the blood-pressure to between 200 and 300 mm. Hg., and thereby increase bleeding and aggravate the condition.

Intravenously, $\frac{1}{2}$ cc. is the amount advisable in shock. Intramuscularly, $\frac{1}{2}$ to 1 cc. is effective in an average case. The injections are repeated as indicated by the trend of the blood-pressure curve.

(ii) *Insulin.* Since the blood sugar is raised by anæsthetics, operations and injuries, insulin 10 units is given three times during the first twenty-four hours after the administration of glucose by the rectum, subcutaneously or orally. This enables the tissues to utilise glucose.

(iii) *Cardiac and respiratory tonics.* Digitalin $\frac{1}{100}$ - $\frac{1}{50}$ gr. intramuscularly, or strophanthin $\frac{1}{200}$ - $\frac{1}{100}$ gr. intravenously is probably the most dependable. These drugs do not raise the blood-pressure, but strengthen the heart action and respiration.

Adrenalin, alcohol, strychnine, camphor in oil, and caffeine of routine traditional use are of problematical value.

Delirium in shock Delirium is unusual in secondary shock, but is found occasionally. It generally appears in plethoric individuals, mostly chronic alcoholics. Large doses of morphia or its derivatives are unnecessary and ineffective after a moderate initial dose ($\frac{1}{4}$ gr.). Cardiac tonics intramuscularly—e g. digitalin $\frac{1}{100}$ - $\frac{1}{50}$ gr or coramine 1 to 2 cc —together with brandy $\frac{1}{2}$ to 1 ounce plus paraldehyde by mouth or rectum, will quieten most patients.

Cortin in shock The work of Heuer and Andrus raises the question, " Is cortin of service in human shock ? " The author has worked on this for a year. Its effect is difficult to measure, but its use is encouraging. It has been given in several ways

If 5 cc is given *before operation*, patients have a smooth convalescence. If used prior to a spinal anæsthetic, the fall in blood-pressure is not so marked, while in other patients where the pressure has already fallen an intravenous injection is sometimes followed by a gradual and sustained rise in pressure.

If 5 cc is given with an intravenous saline *after operation*, improvement will follow, especially in old or very debilitated patients and in dehydrated infants, e g with pyloric stenosis.

CHAPTER II

Continuous Drip Blood-Transfusion

by

H. L. Marriott and A. Kekwick

Definition and Main Principles

A continuous drip blood-transfusion is, broadly speaking, a large transfusion administered slowly. The following table summarises the drip transfusions carried out at the Middlesex Hospital during 1935:

Total number of drip transfusions	87
Total volume of blood drip transfused (excluding citrate)	233·5 litres.
Total duration of these transfusions	2,545 hours.
Average volume of each drip transfusion	2·7 litres (=5 pints).
Average duration of each drip transfusion	29 hours.
Largest single transfusion	6·3 litres (=11 pints).
Longest single transfusion	62 hours.

These transfusions have been of unprecedented volume and duration. The main principle is that the present conceptions with regard to dosage in transfusion need radical revision, and that transfusion volumes should be regulated by hæmoglobin determinations, with the purpose of restoring the hæmoglobin percentage to the lower limits of normality (i.e. 70 to 80 per cent). The customary transfusion of a pint (568 cc.) to an adult can only increase the hæmoglobin percentage by 10. This is woefully inadequate in severe anæmia, particularly if bleeding is still in process. When adequate volumes of blood are transfused, the improvement is commensurate. Large transfusions necessitate very slow administration to avoid circulatory overloading. Rapid transfusion is only safe if rapid bleeding is occurring. If transfusion is sufficiently slow, the blood volume is not significantly increased. Boycott and Oakley, working upon rabbits, found that after large transfusions the plasma volume was returned to normal in one or two days by the compensatory extrusion of the added plasma—the added cells only were retained in the circulation. This plasma extrusion and corpuscle retention occurs during transfusion if the administration is sufficiently slow. The hæmoglobin percentage rises in proportion to the added red cells without dilution effect from the added plasma.

A rise of 10 per cent every four hours should be regarded as the maximal permissible rate of hæmoglobin increase. In a non-bleeding adult such a rise means a rate of forty drops per minute (=a pint in four hours). In a bleeding patient this rate must be added to the rate of bleeding as roughly determined by hæmoglobin

estimations or clinical appraisal. In children the rate must, of course, be reduced in proportion to the body weight. Very weak patients or subjects of cardio-vascular or respiratory disease require a slower rate, and the hæmoglobin should be raised to normality by stages of not more than 30 per cent at a time, with resting intervals of several days.

Donors. All donors must be of the same group since their bloods are mixed in the reservoir. If possible, they should also be of the same group as the patient. We have on occasions used Group IV (Moss) donors for a non-Group IV patient without mishap. Standard sera used for grouping must be of high titre in regard to agglutinins (at least 1 in 50) Reliable standard sera are supplied by the British Red Cross Blood Transfusion Service. This serum gives more reliable results than cross testing of donors against recipients or against each other, since many individuals' sera are of very low titre. Our practice is to use the direct test with the recipient's serum merely as a first rough sieve for the donors to save expense in regard to standard sera.

In the above series of 87 drip transfusions, 390 donors were used—an average of 4½ per transfusion Three hundred and thirty-three were relatives or friends of the patients, and only 57 were from the Red Cross Service. Since the adoption of the practice of making relatives responsible for finding donors little difficulty has been experienced in obtaining them. We explain that it is their duty to secure ten or a dozen volunteers and that we do not accept a responsibility which is rightly theirs.

Surgical Indications

(1) *Pre-operative drip transfusions* Severe anæmia markedly increases the danger of any major operation. This risk can be removed by pre-operative drip transfusion of an adequate amount of blood. The pre-operative drip transfusions at the Middlesex Hospital in 1935 were in connection with the following types of cases :

Bleeding peptic ulcers	13
Carcinoma of stomach . . .	4
„ „ cæcum . .	3
„ „ cervix . .	1
„ „ bladder . .	1
Splenectomy for hæmolytic anæmia .	3
Fibroids	2
Colitis (1 stenosis, 1 gastro-colic fistula)	2
Amputation of leg . . .	1

Four patients also received drip transfusions prior to radium or X-ray treatment.

(2) *Drip transfusions during operations.* The ease of control of the drip method makes it suitable for use during operations accompanied by considerable bleeding. Three or four pints of blood are collected before the operation. At the outset of the operation the cannula is tied into the vein by an assistant, who, during the rest of the operation, notes the bleeding and adjusts the rate of the blood drip accordingly. He frequently checks his estimates by hæmoglobin and blood-pressure determinations. Thus the patient leaves the table without having lost blood from the circulation, and so the hæmorrhagic element in surgical shock is eliminated. During a prolonged intra-cranial operation we have in this way administered five pints of blood.

(3) *Post-operative drip transfusions.* Drip transfusion can be valuable in combating post-operative hæmorrhage or in rectifying anæmia in septic post-operative conditions. In 1935, at the Middlesex Hospital, 8 cases of severe post-operative bleeding received very large drip transfusions; these followed gastrectomy 3, nephro-lithotomy 2, prostatectomy 1, hysterectomy 1, and dental extraction 1.

Apparatus and Technique

(1) *Bleeding donors.* The method used should be a closed one so that infection of the blood may be avoided. It should also be efficient enough to obtain the full quota from each donor. The apparatus we use is illustrated in figure 2932. The *blood is aspirated by strong suction provided by a Dunlop "Junior" motor tyre* foot pump with its valve reversed; by its use, 600 cc. may be obtained within five

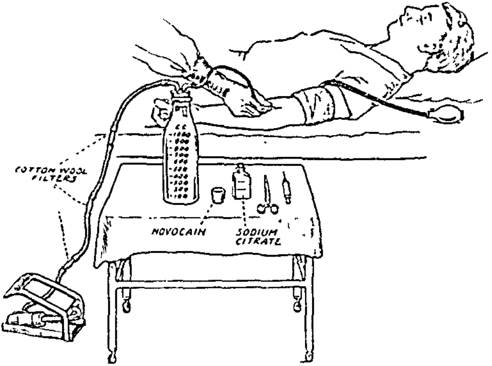


Fig. 2932.—CONTINUOUS DRIP TRANSFUSION BLOOD COLLECTION.

minutes. Rapid bleeding of donors causes fewer reactions than slow collections, provided that not more than 50 cc. per stone of body weight is withdrawn (e.g. 600 cc from a twelve-stone person), because reactions are generally psychological and proportional to the time taken. The blood is collected in a quart milk-bottle graduated in cc. and fitted with a rubber bung. Only pressure tubing is used, for thin-walled tubing collapses under suction. The connection between the bottle and pump *contains sterile cotton-wool filters whose function is to prevent infection* of the blood by the slight blow-back at the beginning of each stroke.

A Keynes' needle is advised; *it must be sharp* (see fig. 2934c).

The donor is recumbent. Before scrubbing up, the operator applies a sphygmomanometer cuff to the donor's arm and swabs the elbow flexure with spirit. He also connects the pump to the end of the sterile tubing. After scrubbing and donning a sterile gown and gloves, he isolates the area of the vein with sterile towels. Manipulating the sphygmomanometer bulb through the towels, the cuff is inflated

to a pressure of 70 mm. Hg. He next inserts the needle into sterile 3·8 per cent sodium citrate solution, and, by pumping, sucks 50 cc. into the receiving bottle. A pair of artery forceps is then clipped on the tubing between the needle and the bottle, and a good partial vacuum is developed in the bottle by vigorous pumping for half a minute. A wheal is raised over the vein by intradermal injection of a few drops of 1 per cent novocaine. Through this area the Keynes needle is thrust into the vein. The artery forceps are unclipped, and blood shoots through the glass connection and a moment later streams into the bottle. The donor should strongly clench and unclench his fist about a dozen times a minute. The bottle

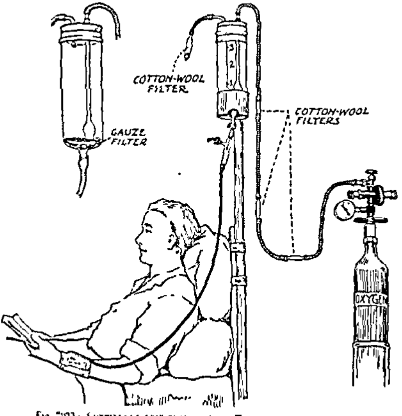


FIG. 2933.—CONTINUOUS DRIP TRANSFUSION. THE INFUSION ARRANGEMENT.

needs to be shaken frequently to mix the blood and citrate. It is only necessary to give a few occasional pumps as the bleeding proceeds until the required amount is obtained.

(2) *The administration of the blood.* The principal difficulty in the use of citrated blood for drip infusion, as compared with saline, is that the corpuscles tend to sediment in the reservoir. Continuous aseptic stirring of the blood is therefore necessary. This has been achieved by bubbling a continuous stream of filtered oxygen through the blood.

The apparatus used by us is illustrated in figure 2933, and consists of:

(*a*) An oxygen cylinder fitted with a pressure regulator and fine adjustment tap.

(*b*) Five feet of rubber tubing, interspersed with three filters filled with cotton wool, which connects the cylinder to:

(c) A glass *reservoir* (*four-pint capacity for an adult, half-pint for an infant*) fitted with a rubber bung. The tube from the cylinder is attached to an *inverted thistle funnel of 1½ inches in diameter* which passes through the bung and reaches to within ½-inch of the bottom of the reservoir. Also passing through the bung is a very short tube connected to a cotton-wool filter; this serves as an outlet for the oxygen. The base of the reservoir is fitted with a circular wire gauze filter made of 28 gauge pure nickel wire, with twenty meshes to the inch, which serves to strain off any clots. The reservoir fits into a tin holder for suspension.

(d) Four inches of rubber tubing, fitted with an adjustable screw clip (the regulator clip) which connects the reservoir to:

(e) A *drip-bulb of special design* (fig. 2934*a*). *The tubing attached to the*

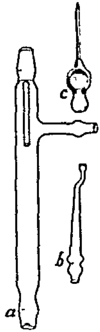


Fig. 2934.—CONTINUOUS DRIP TRANSFUSION.
(*a*) The drip bulb.
(*b*) The cannula for the recipient.
(*c*) Donor needle.

Fig. 2935.—SUITABLE VEINS FOR DRIP TRANSFUSION.

side-arm *must make an airtight joint*. The screw clip on it is usually tightly closed.

(*f*) Another four inches of tubing and glass connection joining the drip-bulb to:

(*g*) Six feet of *pressure* tubing of 5 mm. external diameter (aspirating tubing) attached to:

(*h*) A cannula of special design (fig. 2934*b*) which can be tied into a vein without kinking it. It is made in three sizes.

All the items of apparatus, except (*a*) and the tin reservoir holder, require sterilising and may conveniently be baked in a dressing tin along with a gown, gloves, towels, dressings, and the instruments mentioned later.

The first step is the selection of a vein. Our usual choice is one of the veins

in the distal third of the forearm usually along its radial border (see fig. 2935). Such a vein does not necessitate splinting the arm as is the case with ante-cubital veins. The vein being chosen, the reservoir holder is suspended at a height of 3–4 feet above the vein. An adjustable stand is a convenience. The oxygen cylinder is placed close by. The patient's forearm is cleansed with spirit and a sphygmomanometer cuff applied to the arm and inflated to 40 mm. Hg. The lid of the dressing tin is opened.

At this point the operator scrubs up and puts on a sterile gown and gloves. He then inserts the reservoir into the holder and connects up the tubing (see fig. 2933). The cannula is laid upon the sterile towels isolating the vein area. The regulator screw clip above the drip-bulb is left wide open, and a pair of artery forceps clipped across the tubing about two feet proximal to the cannula. It is convenient to start proceedings using saline rather than blood. An unsterile assistant pours sterile saline to a depth of ½ inch into the reservoir. The artery forceps are released for a few moments to allow saline to run through the tubing

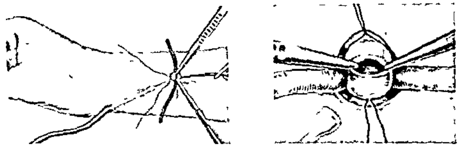


Fig 2936.—Drip transfusion. Inserting the cannula into the vein. (*Marriott and Kekwick.*)

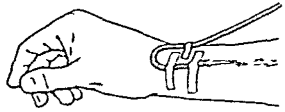
and expel the air in it. Air, of course, permanently remains in the upper part of the drip bulb which is an air lock. The forceps are reapplied after the minimum waste of saline.

Two cc of 1 per cent novocaine is injected, partly intradermally and partly subcutaneously, and a *transverse* incision ¼-inch long is made over the vein. The vessel is displayed by blunt dissection with fine artery (spider) forceps. The forceps are then thrust under the vein and a piece of thin rubber tubing pulled back under it; the tubing serves to keep the vein presented (fig. 2936). The distal end of the vein is ligatured, the ends of the ligature being left long, and another ligature is passed around the proximal end and left untied. The tourniquet is now deflated—an easily forgotten point.

The vein is cut half across with scissors and the lumen displayed. Any bleeding is controlled by traction on the untied proximal ligature. The cannula is now inserted, its insertion being facilitated if the vein is held open in the following manner: A pair of fine artery forceps is clipped on to the right-hand wall of the vein and left loosely hanging, while the left-hand wall is held up by dissecting forceps in the operator's left hand. The cannula having been introduced, the proximal ligature is used to tie the vein over it between the bulbous tip and the shoulder The long ends of the distal ligature are tied around the other side of the shoulder. The ends of both ligatures are cut and left about 1½ inches long. The artery forceps occluding the pressure tubing are removed, and the flow in the drip-bulb cut down to a rapid drip by adjustment of the screw clip. Strips of strapping

fix the cannula and tubing to the forearm (fig. 2937). Sterile gauze and wool are bandaged on firmly below the cannula but lightly above it so that the vein is not compressed. Blood is poured into the reservoir, and its rate of drip adjusted by the regulator screw clip. The flow of oxygen is started. The big bubbles escaping from the thistle funnel make faintly audible "plops"; forty "plops" a minute ensure adequate stirring without too much frothing. The nurse must be instructed to inspect the drip every ten minutes, and to adjust the regulator screw clip if the flow slows. *She must not allow it to stop, or clotting will occur in*

Fig. 2937.—Continuous drip transfusion.



the cannula from reflux of uncitrated blood. Apart from occasional adjustments of *the clip and periodic replenishing of the reservoir, there is no need for her to touch* the apparatus. The tubing is so long that the patient can use his arm freely and lie in any position.

(3) *Alternative Apparatus.* Henry and Jouvelet's electric motor pump may be used instead of the gravity apparatus already described, the rate of transfusion being indicated by a cyclometer instead of by a drip-bulb. The pump gives a steady delivery, but has the disadvantage of being costly.

Difficulties and Complications

(1) *Rigors.* It is very important that the citrate and saline solutions used should be prepared from distilled water entirely free from dead organisms, as otherwise troublesome rigors are inevitable. Also all the tubing used must be free of stale blood from former transfusions, and it is best to use new tubing for each transfusion. If these precautions are observed rigors are rare.

(2) *Creeping up of blood in the drip-bulb.* This may occur after several hours, but the side-arm on the drip-bulb is there to deal with it. The regulator clip should be closed and the side-arm clip opened for a moment or two till the blood level has sunk, under atmospheric pressure, to the bottom of the drip-bulb.

(3) *Phlebitis.* In ten to forty hours, usually twenty-four hours, phlebitis affects the vein. The patient complains of pain, especially if the drip is accelerated. Red and tender induration slowly spreads up the arm. The temperature rises. The phlebitis appears to be an irritative and not an infective phenomenon. When it *begins* the cannula should be changed to the other arm. Persistence with the same vein may cause a very painful limb and sharp constitutional disturbance. Fortunately, most drip transfusions are completed before phlebitis develops, but changing the cannula is a simple matter.

(4) *Clotting in the Cannula.* Clotting in the point of the cannula occurs if the drip is allowed to stop. As a rule, the tiny clot can be driven on and the drip restarted by sharply nipping the tubing two or three times between finger and thumb close to the patient's arm. If this fails, 10 cc. of sterile saline are *sharply squirted into the tubing by means of a fine hypodermic needle at the point* where it emerges from the bandages. Artery forceps should be clipped across

the tubing just above the hypodermic needle so that none of the force of the squirt is lost by backward transmission.

(5) *Pulmonary œdema.* If a drip transfusion is run in too fast, circulatory overloading may occur, and there is also a danger of pulmonary œdema. The first signs are development of a persistent cough and the appearance of râles at the bases. The drip should be stopped at once. In our experience, now amounting to one hundred and fifty drip transfusions, we have seen two slight cases and one severe case of pulmonary œdema. This complication should not occur if a rate of hæmoglobin increase of 10 per cent four-hourly is regarded as an absolute *maximum*, and if in the subjects of cardio-vascular or respiratory disease or cachexia the hæmoglobin is not raised more than 30 per cent at a time and the patient is watched very carefully during transfusion.

The difficulties and complications of drip transfusions have been faithfully described for the help of readers who may perform them. In practice, however, they are small and of negligible importance when weighed against the remarkable benefit to the recipients.

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CHAPTER III

Treatment of Hæmophilia by Snake Venom

Hæmophilia is a blood disease which runs in families, affecting male members and being transmitted to them through the female. Its chief characteristic is profuse and continuous capillary bleeding following a wound in any part of the body. This hæmorrhage may continue for days or even weeks from blood-vessels, either internal or external, especially those in and about joints; a fatal issue is not uncommon.

Pathology. Investigation of hæmophiliac patients shows that the tissues are approximately normal, and no abnormality is detected in the quality or quantity of the blood-platelets. The bleeding time is prolonged from five to fifty minutes against the usual three and a half minutes. When the blood clots it is soft, friable, shaggy and non-adherent. The unscientific conclusion arrived at is that in hæmophilia there is a "functional peculiarity of the blood."

Previous Treatment.

(1) *General.* A blood-transfusion, repeated several times if necessary, has so far proved the most useful remedy in hæmophilia.

(2) *Local treatment* The local treatment of true hæmophilia is usually ineffective. Many remedies have been tried, such as the use of tourniquet (bleeding restarts on release), the application of cold turpentine or adrenalin compresses, cautery, diathermy, or suture. All these may be temporarily effective, but they have the common disadvantage of devitalising the tissues, thus extending the wound, and so aggravating bleeding and preventing healing. A further handicap in hæmophiliacs is that, when the blood condition is known, surgery is postponed as long as possible: thus teeth or tonsils, etc., become grossly septic, and the surrounding tissues infected, congested and friable—a bad operation field!

Treatment by snake venom. Various workers have noted that certain snake venoms cause intra-vascular clotting. Recently, McFarlane and Burgess Barnett (*Lancet*, 1934, II, 985) tested it on hæmophiliacs, using venom from various snakes. They found that the poison of the vipers, especially of the vipera Russelli, consistently coagulated hæmophiliac blood. The venom is so potent that hæmophiliac blood, which normally clots in thirty-five minutes, is coagulated in seventeen seconds. Further, the resulting clot is firm and tough as contrasted with the usual soft mass. Both the serum and the corpuscles are coagulated independently.

Venom dilution. Viper venom diluted to one in one million (1 in 1,000,000) causes clotting in sixty seconds, which is adequate for clinical purposes; the coagulating agent must be effective in weak solutions because it is diluted by the blood, lymph and saliva. In the extreme dilutions of one in one thousand million (1 in 1,000,000,000) clotting occurs in six minutes.

Venom toxicity. The toxicity or otherwise (on the subject and on the tissues)

of the viper venom used as a coagulant has necessarily been determined. Fortunately no deleterious constitutional effects have occurred, neither has the wound been irritated nor healing delayed.

Venom and temperature. An aqueous solution of venom loses its coagulative power when boiled, but heating to 50° C. enhances its effect—a practical point for resistant and infected cases.

The stability and sterilisation of venom. Aqueous solutions of 1 in 10,000 venom quickly deteriorate, especially if they are warmed or further diluted; consequently, for clinical purposes, the 1 in 10,000 solution is evaporated into an ampoule, after which a slight white powder remains. In this form it will keep for months and will make potent solutions with warm sterile water. Boiling and preservatives destroy the coagulating power of the venom, but passage through a Berkefeld filter sterilises it without impairing its coagulating properties.

Venom in clinical use. To arrest persistent bleeding two conditions must be satisfied: a firm clot must form to stop the hæmorrhage, and the wound must heal or the bleeding will recur. Snake venom is applied locally in a standard dilution of 1 in 10,000. It is effective in all cases of hæmophiliac bleeding and in other continuous hæmorrhage. It may be used with advantage after tonsillectomy and tooth extraction, and for epistaxis, post-operative bleeding in the nasopharynx and wounds about the body. Where teeth must be removed from hæmophiliac patients, admission to hospital is arranged for the purpose of preliminary mouth washes, blood-transfusion, and application of the venom, after which, if the treatment is correct, bleeding will be slight.

The technique of the venom treatment. The wound—e.g. a *tooth socket*—is gently but thoroughly cleared of pus, blood and debris by iced saline or hydrogen peroxide. A piece of wool soaked in 1 in 10,000 venom is inserted lightly on to the whole of the bleeding surface. The hæmorrhage quickly stops and a firm clot remains. If the bleeding is brisk, light pressure is permissible while coagulation takes place; if the venom at ordinary temperatures is not effective, it is warmed to 50° C. Splinting of the part or area by bandaging and other methods—e.g. a dental plate—is essential to keep the dressing in position and the clot intact, but pressure on the wound must be avoided.

Precautions:

(1) *The dressing* must not project from the wound, as movement may dislodge it, together with the clot, and thus restart the bleeding.

(2) *Pressure or tension* on the wound by plugging, dressings, splints, bandages, or by a dental plate must be avoided so that the viability of the tissues and therefore their power of repair is undiminished.

(3) *Sepsis.* When sepsis is present the venom dressing is changed once, twice, thrice or more often daily to minimise soiling and tissue destruction by bacterial action which would prevent the wound from healing.

(4) *Adrenalin* is never used because it exerts a deleterious effect on the tissue viability even though it may be temporarily hæmostatic.

Suturing. McFarlane (*St. Bartholomew's Hospital Reports*, 1935, LXVIII, 229) writes: "No sutures should be employed unless it can be guaranteed that they will not cut out nor lead to the formation of a hæmatoma. In certain cases

sutures may help, but closing the skin over bleeding points which cannot be controlled is bound to lead to an extensive hæmatoma."

General treatment. The mental tranquillity and co-operation of the patient are essential for a successful issue. This is achieved by an explanation of the problem and by repeated assurances; the latter are necessary when the bleeding is prolonged and recurrent.

CHAPTER IV

GANGRENE

THE term *gangrene* is applied when the whole or part of an organ dies. It may result from an injury or during the ensuing inflammatory reaction. The gangrenous process includes the blood-vessels, the lymph vessels, the epithelium, the connective tissue, the muscle, the nerves, and the bone of the part. Gangrene is thus a massive or macroscopic condition; frequent examples are acute gangrenous appendicitis, and a toe or foot in senile arterial disease.

Necrosis is the term describing death of tissue in small amounts; it is an affection of cells rather than of parts, e g. tiny fragments of bone, of skin, or of kidney. The word is frequently used synonymously with gangrene, and a clear differentiation between the two is not always easy. Both gangrene and necrosis develop in the course of inflammation, and they have common causes.

When epithelium is affected, the term ulceration may be used for necrosis and may be defined as molecular necrosis of an epithelial lining. Necrosis of tissues takes place after operation, due to crushing by artery forceps, or to tightly tied sutures and ligatures which cut off the blood supply. Necrosed tissue, unless considerable, is frequently absorbed during the inflammatory reaction without being cast off externally, e g a small piece of kidney or fat, or a small sequestrum. The heart, kidney, lungs, spleen and brain are liable to insults which result in necrosis, usually following an embolus or thrombosis of an artery. When an embolus (sterile or infected) lodges, an adjacent section of the organ is deprived of its blood supply, and an infarct, usually conical in shape, forms. If it is small and aseptic it is usually absorbed completely, a fibrous scar remaining; but if it is only partially resolved, liquefaction may take place with cyst formation, especially in the brain, or occasionally the area becomes calcified. Should the embolus be septic, then an abscess develops.

CLINICAL TYPES OF GANGRENE

Gangrene is described clinically as "wet" or "dry," the distinction depending on the presence or absence of *active* infection in the part.

Dry gangrene Gangrene is declared dry when the area is shrivelled, dry, hard, greasy, black and mummified. The dark colour is caused by the decomposition of hæmoglobin. Organisms are certainly present, but the conditions are unfavourable for their growth, and there is little macroscopic or microscopic evidence of their activity.

Wet gangrene. Wet gangrene is diagnosed when the circulation has ceased and the part is turgid with fluid. Thus, although active infection is not immediately apparent, the conditions are suitable and it is almost inevitable. As bacterial activity develops, the skin becomes discoloured—yellow, brown, greenish and black, and superficial and deep putrefactive changes with gas formation are quickly evident.

An essential factor of distinction between wet and dry gangrene is the amount of fluid, i.e. of blood or of lymph, in the diseased member. When the arterial supply is cut off, e.g. by calcification, obliteration of the main vessel, or by embolus, the blood and lymph already in it drain out, thus exsanguinating the part and initiating a dry gangrene.

By contrast, death follows interference with both the venous and arterial circulations, such as by traumatic or inflammatory œdema, so that the flow is arrested. The part still contains a considerable volume of lymph and blood, but it is stagnant and constitutes an excellent culture medium for the growth of the organisms almost invariably present, especially if the lower extremity is affected. When the infective element is gross, the term "moist septic gangrene" is occasionally used. Actually gangrene is due to: (1) The cessation of the circulation of blood in the area; (2) varying combinations of impaired blood supply and infection, e.g. gas gangrene after a lacerated wound, acute osteomyelitis etc.

It is worthy of emphasis that it is the arrest of the circulation which is the exciting factor in gangrene, for a part may be almost deprived of blood, yet with a meagre circulation life may continue; on the other hand, a limb may be engorged *with blood, but because the circulation is arrested death follows.*

CAUSES OF GANGRENE

(1) *Constitutional.*

- (a) *Cardio-vascular disease.* Myocarditis, arteriosclerosis, atheroma, calcification, aneurysm, embolism, peripheral arterial disease, Monckeberg's degeneration, Raynaud's disease, and thrombo-angeitis obliterans.
- (b) *Metabolic disease.* Diabetes.
- (c) *After exhausting illness.* Typhoid (acute arteritis), pneumonia, and typhus.
- (d) *Nerve disease.* Peripheral neuritis, hemiplegia, paraplegia, tabes, leprosy, and syringomyelia.
- (e) *Toxic.* Ergot poisoning.
- (f) *Agranulocytosis.* Affecting the oro-pharyngeal cavity, vagina, rectum, and sloughing wounds.

(2) *Local Causes.*

- (a) *Traumatic.*
  - (i) Physical—sharp, blunt or crushing, direct or indirect.
  - (ii) Thermal—cold, heat, light, electricity, explosions, X-rays or radium.
  - (iii) Chemical—acids, alkalis or corrosives.
  - (iv) Biochemical.
- (b) *Infective—acute.*
  - (i) Acute non-specific—boils, carbuncles or cellulitis.
  - (ii) Acute specific—erysipelas, gas gangrene, noma, phagedena, or post-operative progressive gangrene.
  - (iii) Gangrene of internal organs—the appendix or gall-bladder.

(8) By operation for an arterio-venous aneurysm which does not include a fourfold ligature, i.e. of the artery and vein at the entry and exit.
(9) Due to an overlooked or too-long-applied tourniquet.
(10) From tight splints, bandages or plaster, resulting in patches of gangrene over bony points, e.g. the malleoli or the heel.
(11) After prolonged, unrelieved body weight, causing a bedsore on the sacrum, shoulders, heels, crest of the ilium, or the occipital region of the scalp, especially in cases of marked shock, in very stout, very thin, or aged patients, and also in cases of paraplegia, tabes, anterior poliomyelitis, and injury to the spine, causing incontinence.
(12) Gangrene from local spasm of blood-vessels. Carbolic acid compresses on the fingers, nose, toes or penis cause a spasm of the vessels followed by thrombosis, associated with tissue poisoning. A compress of 1 in 100 carbolic will start gangrene in twenty-four hours, 1 in 50 in twelve hours.
(13) Segmentary spasm of the main artery after gross trauma to a limb This is a rare condition described by Finalij and Reichle. The main vessel is thrown into marked contraction for a period of twelve to thirty-six hours, and gangrene of a part may be caused by deprivation of blood during this period.

Gangrene does not necessarily follow all these injuries and operations. A cardinal factor is the age and general condition of the patient. Young, healthy subjects with strong hearts and elastic arteries will compensate and recover after gross injuries, whereas older and debilitated subjects will lose a limb after a simple fracture or other average injury. A crushing injury, damaging the collateral circulation, is more likely to cause gangrene than is an incision, a penetrating wound, or a ligature. The anastomosis in the leg is not so good as that of the arm, so that tissue death is more frequent in the lower limb. Patients with constitutional disease, e.g. chronic nephritis, arterial disease, anæmia, and diabetes, have diminished powers of repair after injury.

SIGNS AND SYMPTOMS OF GANGRENE

Signs of Impending Gangrene

Appearance. The affected part is white or cyanosed; it may be mottled or bluish, and blebs or bullæ may appear on the skin.

Temperature. The suspected area is colder than elsewhere; the level of warmth may be found to be receding or advancing, and should be marked with a skin pencil at each examination.

Pulsation. There is no pulsation detectable in the affected limb. In a shocked patient, however, pulsation is only discernible with difficulty in any part except at the heart and the common carotid arteries.

Anæsthesia. The tactile sense and muscle power are lost or impaired. They are tested periodically, and may be found either to improve or to disappear.

Pain. Severe pain in the affected limb is experienced in some cases, and its presence without adequate cause is significant of threatened gangrene. Thus, if after a fracture has been reduced and splinted pain continues, then gangrene is a likely possibility. Local tenderness and pain traced accurately to the main vessel after an injury suggest thrombosis. If the pain is local and precisely in

the line of the main artery, especially if it is at a point of narrowing, e.g. the origins of the femoral and profunda femoris arteries, or at the bifurcation of the brachial artery, and there is a pulse present above but absent below the spot, whilst the limb is cold and paralysed, then an arterial embolus is diagnosed.

Blood-pressure. A steady fall in blood-pressure in a limb when compared to the other parts of the body indicates local circulatory failure.

Skiagram. A skiagram of the limb may show a fracture close to the main

FIG. 2910.—SKIAGRAM SHOWING A CALCIFIED POSTERIOR TIBIAL ARTERY IN A CASE OF GANGRENE OF THE TOES.

vessels. The arteries may show as pipe-stems, i.e. they are calcified, in which case little vascular compensation is possible, and gangrene is never far removed (fig. 2910).

Signs of Established Gangrene

Appearance. If the part is bloodless after the circulation is arrested, it will be dead white and shrunken; but if it is engorged with blood, it will be blue, cyanosed and swollen.

Temperature. The limb is cold or rapidly cooling.

Pulsation. No pulsation is detectable in the main artery, and digital pressure on the skin causes no capillary blanching followed by flushing. Wounds do not bleed except when gross, in which case a temporary ooze occurs.

Anæsthesia. The patient is unable to move the part, which is unresponsive to all stimuli.

Signs of Viability

Appearance. The part varies from pinkish-white to red or bluish in colour.

Temperature. The part may be cold but is becoming warmer.

Pulsation, although perhaps faint, is felt in a superficial artery, and the skin blanches white on pressure, regaining its colour on release. A needle prick is followed by bleeding, and a bruise results from a blow.

Sensation and muscle sense return, although not if peripheral nerve or spinal cord injury is present.

Some slight *function* may remain in a severely damaged limb, e.g. a small amount of toe movement, or contraction of a muscle.

Inflammatory reaction. During the course of hours, signs of an inflammatory

reaction to an injury develop: the part swells and reddens, serum is poured out, pain is felt, later pus is formed, and ultimately granulations appear in the surviving tissues.

GANGRENE DUE TO COMBINED CONSTITUTIONAL AND LOCAL FACTORS

Gangrene due mainly to arterial disease is often initiated by trivial local trauma when the blood supply is insufficient for the calls of repair. The inflammatory swelling in some cases increases the destruction by obstructing the already diminished blood supply. Gangrene from a combination of local and general causes arises in :

(1) Diabetes. (2) Gangrene and constitutional debilitation. After pneumonia, typhoid fever, severe typhus, cholera, etc., primary arterial thrombosis may occur, resulting in a degree of gangrene and anæmia. It is due to the weak myocardium, secondary anæmia, damage of the endothelium by the toxæmia, a sluggish circulation, and impaired nutrition. A local infection, e.g. a pustule or boil, may extend into gross sloughing. (3) Nerve disease either local or general does not directly cause gangrene, but by its effect it undoubtedly predisposes to it. Thus division of a sensory nerve, syringomyelia, tabes, anæsthetic leprosy, hemiplegia, etc., impair the general nutrition of the part, and by absence of sensation it is liable to more and severer trauma than is usual, thus forming suitable conditions for infection. Blows and burns are frequent in injuries to peripheral nerves and in syringomyelia. Patients with hemiplegia and paraplegia readily develop bedsores. A tabetic patient with a perforating ulcer of the foot is liable to a spreading destructive infection, or slow gangrene may begin around it.

THE COURSE OF DRY GANGRENE

If the affected part can be maintained dry and free from gross bacterial action, it will remain black, somewhat greasy, and hard. The dead tissue is an irritant to the living part, and at their junction the viable tissues develop an inflammatory reaction, and a bright red line of demarcation sooner or later appears according to the patient's condition. A layer of pus separates them, and the living extremity is covered by granulations. The infection which is always present, if marked, causes sloughing and suppuration and involves the limb extensively above the original level of demarcation, adding considerably to the tissue destruction. Consequently, successive lines of demarcation may form at higher levels. The skin and subcutaneous tissue and muscles are chiefly affected as they have a smaller blood supply than bone. As the gangrene is greater in the soft tissues than in the bone when the sepsis is minimal, a "natural" conical stump is formed, the protruding apex consisting of bone. Left to the natural vital process, separation takes a long time, and the soft parts may be epithelialised before the bone division is complete. A general toxæmia is always present from the sepsis, and pain (always an exhausting symptom) is persistent and severe. The normal course of separation and healing is rarely seen as it is generally eliminated by amputation. The control of the sepsis depends largely on the management of the part. If it is kept dry with air circulating freely around it to ensure evaporation, and spirit antiseptics are applied, it can be preserved completely mummified for considerable periods. On the other hand, dry gangrene may become offensive and wet.

THE COURSE OF MOIST GANGRENE

When a congested part becomes gangrenous, amputation at the earliest moment is necessary in order to avoid a general illness from the toxæmia of the almost inevitable infection. An attempt to exclude infection must be made.

Nursing Instructions

(1) The part is shaved, washed daily with rectified spirit, and a dusting powder is applied e.g xeroform

(2) The part between the toes is cleansed with spirit, a pledget of cotton wool is inserted sprinkled with antiseptic dusting powder, and the nails and folds of the skin are treated similarly.

(3) The limb is slung from a cradle and is exposed to moderate heat periodically during the day, the cradle being arranged so as to ensure continual ventilation.

With these precautions, infection and further destruction may be avoided, and a line of demarcation will appear, usually forming earlier in wet than in dry gangrene In a favourable case, the limb will gradually dry and perhaps mummify, but it is the exception rather than the rule to achieve this in all the fleshy parts. The skin changes colour, blebs appear, and the parts may become crepitant from the gas formed by saprophytic organisms. Ultimately the dermis falls away, followed shortly by masses of soft disintegrating muscle. The bone is exposed and the ligaments yield, exposing joint surfaces.

Infection is often impossible to exclude, and early amputation is performed to avoid further destruction by spreading infection. Gas organisms readily become established, and extension of the tissue loss is imminent, requiring a higher level for amputation (perhaps of the guillotine type), besides the associated toxæmia or even septicæmia Bacteria rapidly track along the tissue planes and main vessels It is not unusual, when dividing the thigh for moist gangrene of the leg and foot, to find œdema in the deep fascia and a sero-purulent exudation about the upper third of the popliteal artery Thus a prompt amputation is necessary to avoid local spread and a serious constitutional illness. A fundamental fact, frequently but tardily realised, is that once a part is gangrenous it is dead, and that by no treatment can it be even partially restored.

TREATMENT OF GANGRENE DUE TO CONSTITUTIONAL CAUSES

Prophylactic Treatment

Patients suffering from myocarditis, arteriosclerosis, atheroma, calcification of the arteries, aneurysm, and diabetes are liable to develop gangrene after the ordinary wear and tear of the daily round, e.g. cutting and manicuring nails, ingrowing toe-nails, paring corns and bunions, small punctures from a nail in a shoe, sore toes or blisters from tight socks, small shoes, and over-exercise. Prolonged exposure to cold, a burn or scald such as from a hot-water bottle, or a knock crush or fall on the foot will also initiate the destructive process.

The repeated application of antiseptics, of caustics (e g. silver nitrate), or of ointments, soaking in hot baths, or scalding fomentations to a minor surgical condition may finally extinguish the flickering life of the part. Once an inflammatory process is initiated the resulting œdema may obliterate the blood-vessels

and so increase the gangrene; the toxæmia of infection is also more potent in these subjects. It is therefore the duty of the doctor to warn possible subjects of the dangers and to instruct them as to the care necessary in manicure and in toilet, etc. During exercise, thick socks, and comfortable shoes or boots with stout soles should be worn. Improvement and relief from spasms of pain usually follow the exhibition of iodides by mouth and diathermy treatment. If the Wassermann reaction is positive, anti-specific treatment is given.

Warnings of impending gangrene are breathlessness on ordinary exertion, giddiness, loss of general strength, "pins and needles" in the limbs, and coldness or shrinkage of the feet which may be blanched or mottled. Painful cramps are felt in the legs after a certain distance has been walked—a distance which tends to lessen. There may be diminished pulsation of the dorsalis pedis artery. Even trivial lesions of the extremities must be treated with care. Without unduly alarming the patient, enough of the threatened danger is explained to ensure that the advice given is carried out faithfully The limb is warmly clad, elevated, and rested in bed or on a couch Strong antiseptics and hot fomentations are never applied.

Treatment of the Early Local Lesion

A dull red area may appear on the great toe, or less frequently on the second or third toe. Small wounds, which normally attract little notice or attention, fail to heal, merely crusting over a painful process which may persist for months. The part is kept elevated. If pus forms, hypertonic compresses and warmth from a radiant heat lamp are applied. Bier's passive hyperæmia is arranged for twenty-two out of the twenty-four hours. When a scab forms on the wound, it is not disturbed but touched sparingly once a day with weak tincture of iodine or 2 per cent mercurochrome, and protected by voluminous dressings. With this care, healing may follow in a few weeks rather than days; any attempt to hurry it may do harm

Other remedies are diathermy to the legs (probably the most efficacious), also cautious exposures to ultra-violet and infra-red rays.

For the cardio-vascular condition, alcohol is permitted in small quantities, tobacco is limited, and the diet is light and estimated to satisfy comfortably the caloric requirements of the body, over-eating is avoided. The urine is examined for albumen, pus and sugar, and appropriate treatment is given as required. Occasionally pain is persistent. Sedatives are given to ensure sleep at night and comfort during the day, but the opium derivatives are avoided as long as possible. By intelligent treatment potential gangrene may be averted for months or even years.

Treatment of a Small Patch of Gangrene

In spite of assiduous attention, an area of gangrene may appear on the toe. The measures described are continued, no wet dressings are permitted, and the part is kept absolutely dry with antiseptic dusting powder. Painting lightly once daily with weak iodine tincture or similar non-irritant drying antiseptic is useful. Occasionally it is possible to arrest the gangrene; the black scab separates, and slow healing follows, or an indolent ulcer remains.

Indications for Amputation in Gangrene

The question of local amputation arises. The policy adopted depends on three factors:

(1) *Social status.* Good conditions permitting care and protection without the necessity to work, etc., favour a local removal. When means are limited and the surroundings are unfavourable, then the minor procedure is likely to be unsuccessful and recurrence will follow with the wear and tear of the daily round. When it is essential for the patient to be equipped for regular work, high amputation with the provision of an artificial limb is the most dependable treatment.

(2) *The arteries.* If pulsation is detectable in the dorsalis pedis and posterior tibial arteries and the gangrene is dry, a local amputation will probably heal. When pulsation is absent or feeble, e.g. especially in calcified arteries, reaction around the gangrenous area and healing in an amputation close to it will be delayed and weak, or even absent—a high level amputation is indicated.

(3) *Infection.* When infection is present, with or without pulsating arteries of the foot, a local amputation is contra-indicated. If pulsation is present, smears of the discharge are taken at regular intervals, and when they show steadily diminishing colonies grown on culture, a more conservative amputation may be performed, e.g. below rather than above the knee. The organisms should be identified, and prophylactic injections of autogenous vaccines should be given before operation. In gangrene with infection and calcified arteries, a high section is required at an early date. Long experience has shown that section through the junction of the lower and middle thirds of the thigh is satisfactory and superior to division below the knee.

Amputation for Diabetic and Senile Gangrene

Amputation for gangrene due to diabetes and to senile arterial disease is a major surgical problem. The subject, with special reference to diabetes, was studied and discussed by McKittnick and Pratt (*Ann. Surg.* Oct. 1934, 630). These authors analysed the results of amputation for diabetic gangrene in 396 patients with 496 gangrenous conditions, i.e. both limbs were affected in a proportion. Their findings apply equally to amputation for gangrene due to cardiovascular disease and to infections in subjects over fifty years of age.

If untreated, diabetic gangrene is always fatal, for it is a local indication of widespread vascular and constitutional disease, so that preservation of the affected part is but a secondary consideration when the absorbed sepsis is imperilling the life of the whole. By early amputation, a smaller immediate and remote mortality is secured. Better functional results follow this policy. The pain in gangrene is frequently severe, which is another reason for refusing to wait for the natural separation of a part even if the gangrene is dry. The close co-operation of the physician and the surgeon is essential for a successful issue of the treatment.

Diabetic gangrene is of two types:

(1) *Dry gangrene*, usually found in subjects over fifty-five and associated with arterial disease.

(2) *Wet gangrene*, often infected, but with good arteries; usually occurring in younger subjects. Here the prognosis is better.

Diabetic Gangrene with Infection.

The combination of diabetes, a pulseless foot, gangrene, local infection, and lymphangitis is a dangerous one, and unless a carefully-planned early amputation

is performed after detailed preparation, septicæmia and death follow. The more active the infection, the earlier amputation is required. Infection by gas-forming organisms is usually present, and as septicæmia occurs in a fair porportion of cases, a blood culture should be taken without delay.

Treatment.

When lymphangitis is present above the gangrenous part, the limb is treated with hot antiseptic hypertonic compresses for twenty-four hours, when, if the lymphangitis and inflammation show signs of subsiding, amputation is performed through the lower thigh and the wound is closed; but if the infection continues unabated, a guillotine amputation through the upper third of the leg is carried out, and the wound is left open. The removal of a septic, painful, and gangrenous limb is better immediate treatment for the cardiac and renal inefficiency which accompanies diabetes than is persistence with medical measures.

Mortality.

McKittnick and Pratt found that the mortality of operative interference in all cases is about 11·5 per cent. In patients with gangrene and arterial disease it is 14 per cent, as contrasted with 7 per cent in subjects with infection but with good arteries, i.e. with adequate blood supply to the extremities. Of 57 deaths, 18 were due to septicæmia, 14 to infection of the stump or elsewhere, and 20 followed cardiac, respiratory or renal lesions. The survival rate for two years and over is surprisingly low, being only about 33 per cent, a fact which once again emphasises the gravity of the general illness.

TREATMENT OF GANGRENE DUE TO LOCAL CAUSES

These cases are, broadly speaking, due to some form of trauma, sometimes following fractures; the gangrene is frequently wet in type. Treatment resolves itself into prophylactic measures and amputation.

Prophylactic Measures

After certain accidents gangrene is soon seen to be inevitable, but sometimes it is only a possibility, in which case careful watch is kept for the signs of threatened gangrene as already enumerated. A timely exploration will avert or reduce the extent of the gangrene. The urine is examined for sugar.

Three operative measures are available:

(1) *Embolectomy* (see also page 1019). Gangrene may be due to a thrombus formed at the site of the injury, which becomes detached and lodged distally. For this condition embolectomy should be considered.

(2) *Periarterial sympathectomy.* If the patient's condition permits, some form of periarterial sympathectomy is performed on the healthy artery above the level of the injury at the same time as the exploration. It may have a favourable effect by causing a temporary vasodilatation to nourish the limb through a few critical hours. Thus, after injuries of the foot and leg, with threatened gangrene, a periarterial sympathectomy on the femoral artery in Scarpa's triangle and in the upper parts of Hunter's canal is performed. Either stripping of the external coat, advised by Leriche, or the injection of absolute alcohol, recommended by Sampson Handley, is carried out. The latter is probably safer as the artery will not be injured and the vasodilatation follows immediately, whilst with the stripping technique, constriction for several hours precedes the increased blood flow. The

effect is transient in either case, but pain is relieved for a time. When gangrene is present, the measure is useless, and early amputation is required.

(3) *Exploration of the traumatised area.* When gangrene threatens after an injury, in view of the inevitable amputation necessary if it occurs, surgical interference, even though it may be heroic, is justified. "Look and see," rather than "Wait and see," is then justifiably the surgeon's guiding principle. That all fractures should be reduced and suitably splinted as soon as possible is a *sine qua non.* The standing order in force in some hospitals, that this treatment must be carried out within four hours of the patient's admission, is worthy of general adoption.

The suspicion of impending gangrene having arisen, a definite intimation of progress to recovery or to gangrene may be obtained by recording with skin pencils, e g. at two-hourly intervals, the levels of: (*a*) altered sensation; and (*b*) modified skin temperature

When gangrene threatens and does not shortly subside, the main vessels at the site of the injury are immediately explored. The objection that such a procedure converts a simple fracture into a compound one, with its attendant risks of sepsis, is, with modern surgical technique, small and negligible as compared with the possible loss of a limb by gangrene. Also, according to Böhler (*Zentralb. f. Chir.*, May, 1933. 1227), it is the best preventative of tetanus and gas gangrene in a compound fracture

During the investigation of the vessels, hæmatomata will be removed, thus relieving lymphatic and venous stasis and encouraging the resumption of these circulations. One of several operations may be necessary:

(*a*) Torn or divided arteries call for repair, either by ligature of the ends, or, if possible, by excision of the injured section followed by end-to-end anastomosis. The latter is possible only when a short length of the vessel is injured. It aims at achieving the ideal, and is occasionally successful (see also page 4084).

(*b*) The artery may be found apparently uninjured but thrombosed. The vessel, after temporary occlusion above and below the block (a tape ligature does this satisfactorily), is opened longitudinally and the thrombus is extracted. The upper ligature is momentarily released to establish that all the clot is removed and that the circulation is present from above. Occasionally more clot is washed out by the pressure of the blood stream. The artery is recontrolled and the lower tape is similarly dealt with If blood flows from below (this will be a rare occurrence after an accident), it will show that the collateral circulation is working and that the continuity of the arterial lumen is established. The vessel wall is sutured with the finest vaselined silk threaded on a slender needle, such as is used for ophthalmic surgery.

When the artery is opened, the intima or media may be seen to be damaged, e.g. a large tear, or a flap of it may be detached; if the occasion is suitable, the injured section is excised and an end-to-end anastomosis is performed. Failing this, the artery is ligatured above and below the injured part and divided.

No attempt is made to close the wound, which is made sufficiently large to gape open, and is dressed with gauze and sterile vaseline, magnesium sulphate and glycerine paste, or 1 in 1000 acriflavine and paraffin emulsion. Silkworm-gut sutures may be inserted and knotted at their extremities, and should the limb recover and the wound be satisfactory, they are tied four to seven days later. If

immediate closure of the wound is considered essential, several incisions extending through the deep fascia are made around it for the purpose of drainage and with the object of relieving and preventing tissue tension which may be caused by extravasations and traumatic œdema.

(c) When a diffuse traumatic aneurysm has formed, a tourniquet is applied above the swelling, but if the swelling is close to the trunk this is not practicable, and the main artery must be exposed through normal tissue close above the lesion, and temporarily controlled by a tape ligature. The aneurysm is incised approximately in the line of the surface marking of the main vessel, the clot is turned out, and the cavity irrigated with iced or hot saline at 115° F., the artery and vein being defined and dealt with as circumstances dictate.

The method advised by the late Sir George Makins, showing the benefit which follows ligature of the main veins of a limb when the chief artery is injured, should be adopted in each case. Usually, however, the vein is already thrombosed, and the ligature is not required.

Finally, and this point is worthy of emphasis, surgery, to be effective, should not be delayed; it must be thorough and radical, and be undertaken in a spirit of optimism. Six to eight hours is the longest time to observe a limb suspected of gangrene before interference, and a careful exploration is unlikely to have any other than a good effect.

AMPUTATION FOR GANGRENE DUE TO LOCAL CAUSES

Gangrene presents in two forms:

(1) The favourable.

(2) The infected.

In the *favourable* form the part has been under skilled observation throughout, and the measures to maintain and improve the patient's strength and to exclude local infection have been successful. Amputation at the selected level, but slightly removed from the gangrene, can be performed, and the wound closed. The prognosis is good.

A typical example of the *infected* form is that of a patient with a fractured tibia and fibula who has been treated by a splint or by plaster and not seen again until five or seven days later, when wet gangrene with infection is established. Three considerations now arise: (*a*) The condition of the limb; (*b*) the toxæmia from the gangrene; and (*c*) the age of the patient.

The problem is akin to that of diabetic gangrene previously detailed. The treatment is amputation. If the sepsis is gross, a guillotine amputation below the knee is performed; if infection is moderate and responding to treatment, the wound may be closed immediately. The section is made above the knee in old or debilitated subjects and below the knee in fit persons.

Toxæmia is present in all forms of gangrene; it depends on the extent of the infection, being especially marked in gas gangrene. Its effect is taken into consideration when timing the amputation, and it compels an early operation. Pain is often a prominent symptom, and vomiting is suggestive of gas infection.

CHRONIC PROGRESSIVE POST-OPERATIVE GANGRENE OF THE SKIN

Post-operative gangrene of the skin is a rare condition which may develop after an operation on the abdomen or thorax for a septic condition. A sub-acute

intractable progressive gangrene of the skin begins at the edge of the wound, spreads irregularly but steadily, and may ultimately involve the entire trunk unless arrested by suitable treatment or by death. Meleney of New York has done a vast amount of research work on this subject, and the reader is referred to the references at the end of this chapter for full details of the literature. Stewart Wallace reviewed the records of thirty-seven cases and gave a detailed account of the characteristics of the lesion. Considerable reference is here made to his interesting article and I acknowledge my indebtedness to him. He suggests that progressive post-operative gangrene of the skin is actually commoner than the small number of published cases would indicate.

Etiology.—The condition follows operations for septic thoracic and abdominal

Fig. 2441.—Chronic progressive gangrene of the chest wall after drainage of an empyema. ("*Brit. Journ. Surg.*")

lesions, more especially after empyema and acute appendicitis, also after operations for breast abscess, perforated duodenal ulcers, subphrenic abscess, drainage of suppurative cholelithiasis, pelvic sepsis, and repair of an incisional hernia (Fig. 2441). A tendency to acholuric familial jaundice has been noted in some of these patients and in their relatives, and appears to be a significant factor. Adults are mainly affected, men about four times more often than women. The Wassermann reaction is negative, and glycosuria is absent. A low standard of general health appears to be a contributory but not a determining factor.

The Arthus phenomenon describes a condition of hypersensitivity of the skin which arises shortly after the injection of sera or protein-shock remedies, when, if further puncture is made during this critical phase, a rapid superficial gangrene and necrosis of the skin around the part takes place. That progressive post-

operative gangrene is akin to such a phenomenon has been suggested. Wallace agrees that it may be a factor, but does not think it will explain all the process.

Pathology. The destruction is limited to the skin and subcutaneous tissues; the muscles and deeper tissues are unaffected. Stewart Wallace writes: "Microscopically the edge of the lesions shows extensive fragmentation of the dense subcuticular connective tissue and a heavy cellular infiltration of the subcutaneous fat. There is no thrombosis of the vessels, which are universally dilated and filled with blood, and a large number of polymorphs cling to the walls. This suggests that gangrene is due to the direct action of some lytic substance on the tissues rather than to a cutting off of the blood supply. Masses of Gram-positive cocci are seen in the centre of the lesions, and scattered organisms in diploform or other chains in the periphery." There is a marked leucocytosis.

Bacteriology. Streptococci have been found in almost all cases, and a fair proportion of them are of a non-hæmolytic strain. Staphylococci were present in an appreciable number, whilst Gram-negative and diphtheritic organisms were often noted. The infection is certainly a mixed one.

Meleney, in two cases, isolated an ærophilic streptococcus from just beyond the œdematous margin of the skin, and a staphylococcus from the sloughs. When these organisms were injected together into a guinea-pig they produced the typical lesion, but when they were injected separately, no effect was produced, even when the punctures were very close together. The staphylococcus is not specific, for other strains injected with the ærophilic streptococcus produced the lesion.

Meleney, Willard and Stewart Wallace consider that progressive post-operative gangrene is caused by the synergistic action or a symbiosis of a micro-ærophilic streptococcus and staphylococcus. The former exists in the human intestine, in peritoneal exudates, in lung abscesses, and in bronchiectatic cavities.

Clinical picture. Within a fortnight of the operation a gradual progressive gangrene of the skin begins in the holes of the tension sutures. The condition advances in spite of the conventional measures such as antiseptic and hypertonic applications, heat, sunlight, and X-ray irradiation, blood-transfusions (immuno and ordinary), injections of arsenic, manganese, antimony and tin, vaccines and sera or protein-shock measures. Tough black sloughs of skin form and, on separating, leave a red granulating base. Unless arrested by treatment or by death, the spreading destruction will involve the whole of the anterior and posterior surface of the trunk and may extend from the occiput to the thighs. It is carbuncular in appearance, and the edges are serpiginous, undermined, raised and swollen, and exquisitely tender. The patient often dies of physical and mental exhaustion, for the pain is continuous and severe. In a favourable case the original wound and stricken area heals from occasional islands of unaffected skin and from undestroyed sweat glands and hair follicles. Considerable scarring occurs. The pulse-rate is increased, and a rise in temperature of 99° to 102° F. is usual. Pain and insomnia are outstanding features, but the appetite and digestion remain good. The toxæmia is not marked, and therefore the patient exists for months before ultimate exhaustion ensues.

Differential Diagnosis.

(1) *Pyogenic wound infection.* In pre-Listerian days, gross post-operative sloughing of wounds was frequent, and even now, if an abdominal wound is tightly closed after a septic condition, e.g. a gangrenous appendix, sloughing cellulitis,

etc., infection may quickly spread into the flanks, groin, or even into the scrotum, but can usually be arrested by incision and drainage. A gas infection is suggested by the smell and the amount of destruction present.

(2) *Erysipelas of the skin of the abdomen and chest wall.* Erysipelas is not a common complication, and necrosis and ulceration are not prominent factors. The general toxæmia is severe and in sharp contrast to the well-being of progressive post-operative gangrene of the skin.

(3) *Hæmolytic streptococcal gangrene.* In hæmolytic streptococcal gangrene, gross sloughing of the skin and subcutaneous tissues occurs, chiefly in the lower limbs, and especially near the buttocks. It may begin after small and sometimes multiple injuries, and may invade the scrotum. The hæmolytic streptococcus can often be cultured from the depths of the wound and from discharges, and also from the blood. Thus it is a septicæmia, and the patient is desperately ill, which distinguishes it from the post-operative gangrene with its usual fair general health.

(4) *Amœbiasis cutis.* An amœbic infection of the abdominal skin follows the rupture of amœbic abscesses and, rarely, an acute appendicitis; it resolves on medication with emetine (Heinberger).

Treatment.

(1) *Prophylactic.* In view of the observation that this type of gangrene begins in the holes of the tension sutures, it is suggested that this stitch should not be inserted in septic abdominal and thoracic wounds; the alternative is approximation of the subcutaneous tissues by fine, non-chromic catgut and closure of the skin by clips, e g. Michel clips.

(2) *Local treatment.* Once the condition is recognised, the treatment is surgical. The advancing destructive edge with a margin of healthy skin and subcutaneous tissue is excised with a cautery or diathermy knife. Copious bleeding follows, and the complete procedure at one sitting is contra-indicated when a large area has to be dealt with; the operation should be completed in several sessions. Cautery applications to the base of the bare area are rarely required. This excision arrests the invasion, minimal areas of destruction follow the operation, the pain is relieved and healing begins. Skin-grafting accelerates closure of the wound. When the erosion is so large that removal of the edge would jeopardise life, an alternative is incision by the cautery or diathermy through the healthy skin down to the deep fascia, leaving a margin between it and the inflamed edge; the resultant gutter is packed with 1 per cent formalin or zinc peroxide.

Prognosis. The outlook depends on the extent of the lesion when it is diagnosed, and on the institution of the correct remedy. Untreated or ineffectively treated, most cases die after months or perhaps a year of continual suffering. Diagnosed early and promptly dealt with, healing and recovery follow progressively. Even when the destruction is large, a well-planned operation with the cautery arrests the inflammation, and recovery ultimately follows, although the mental exhaustion may make the patient a confirmed neurasthenic.

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CHAPTER V

Burns

A burn is a toxic wound associated with much shock, and is almost invariably followed by infection. Burns are caused by heat of all descriptions: dry heat in the form of flame (war-time and mine explosions), gases, hot articles, and molten metal. Fluid heat burns are usually caused by boiling water or aqueous solutions, melted tar, hot oils, and grease. Steam or super-heated steam is occasionally the exciting factor. In industry, boiling chemicals, by their corrosive power, increase the injury of the burn. The higher the temperature, the more extensive and penetrating is the destruction.

The pathology and treatment of burns have made considerable strides of recent years; in Great Britain it is largely due to Mitchiner in London, and to Wilson in Edinburgh, whose findings are freely quoted in this chapter, and I acknowledge my indebtedness to them.

DEGREES OF BURNS

Dupuytren's division of burns into degrees has stood the test of time, and is illustrated by the diagram (fig. 2912).

First degree burns consist of an erythema of the skin. They follow exposure to sunshine, a hot fire, or a fleeting wave of steam or hot gas. A temporary erythema

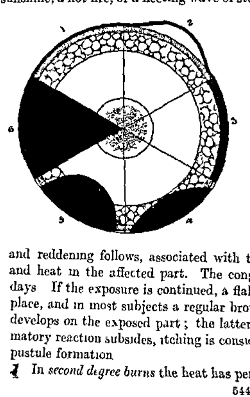


Fig 2912.—Dupuytren's classification of the degrees of burns.

1 = 1st degree, the erythema.
2 = 2nd degree, the blister.
3 = 3rd degree, the true dermis.
4 = 4th degree, skin and subcutaneous tissue.
5 = 5th degree, skin, fat and muscle.
6 = 6th degree, the entire limb is charred.

and reddening follows, associated with tingling, and a sensation of discomfort and heat in the affected part. The congestion subsides in the course of a few days. If the exposure is continued, a flaky desquamation of the epidermis takes place, and in most subjects a regular brown pigmentation, mottling, or freckling develops on the exposed part; the latter may be permanent. Until the inflammatory reaction subsides, itching is considerable, causing scratching and possibly pustule formation.

In *second degree burns* the heat has penetrated sufficiently to cause an effusion

of serum between the epidermis and the dermis, forming a blister. It may be extensive and involve a limb or the surface of the trunk. When the bleb is opened and the covering epidermis removed, the inflamed and sensitive true skin is exposed. Treated correctly, healing without scarring or impairment of sensation occurs, although some alteration and irregularity in the pigment may remain.

Burns of the third degree are declared when the heat destroys the skin and the subcutaneous tissues are exposed. These injuries cause considerable shock by the noxious stimulation of the exposed sensory nerve-endings. Healing takes place by ingrowing epithelium, and also by outgrowths from papillæ which have survived the injury. Treated efficiently a depressed supple scar results, but the colour is not, as a rule, the same as that of the unaffected skin. Sensation is often impaired, and hair growth is scanty and patchy.

A fourth degree burn indicates destruction of the skin and subcutaneous tissue. A hairless, depressed, thin, contracting scar remains.

A fifth degree burn destroys the skin and subcutaneous tissues, and penetrates the muscles. Slow healing and chronic ulceration take place. Some degree of deformity and loss of function follows, and amputation may even be necessary

The sixth degree burn is the most severe, and describes charring of the entire part. Thus skin, subcutaneous tissues, muscles and bone are destroyed. It occurs in furnace accidents, and after explosions, petrol fires, and electrical injuries. A fatal result is frequent, or, if the patient survives, amputation is inevitable. Burns of the fourth, fifth and sixth degrees are brown and charred in appearance, and the tissue beneath is pale and apparently avascular.

EFFECTS OF HEAT INJURIES

The effects of heat injuries are *general* and *local*, described in various stages which merge into one another.

General effects: (1) Shock—primary and secondary; (2) toxæmia—primary from autolysis of burnt tissue, secondary from sepsis; (3) complications—acute nephritis, scarlet fever, gastric and duodenal erosions, mental instability, and neurasthenia; and (4) death.

Local effects: Detachment of epidermis and destruction of tissue; suppuration and separation of burnt parts, repair, ulceration, contraction, painful scarring, and malignant change.

Primary shock in burns is not common, but some patients quickly exhibit it, especially if the burns are severe. It is attributable to three variable factors: (1) the violent painful stimulation of the nerve-endings in the injured area; (2) the inhalation of heated gases and smoke frequently associated with fire or explosion, causing carbon monoxide asphyxiation, irritation of the respiratory passages, and acute conjunctivitis; and (3) the fright and anxiety of the accident.

Wilson found a leucocytosis of about 30,000 in this stage of primary shock; he excluded concentration of blood as the cause.

Unless the lesion is severe, recovery follows gradually on administration of sedatives, warmth, and restoratives. Mitchiner states that in 2 to 2½ per cent of cases death is due to primary shock.

The phase of *secondary shock* develops steadily three to six hours after the burn. The onset depends on the steps taken to anticipate and to combat it. It may last for twenty-four hours without occasioning anxiety, but, if severe, the patient may

become weaker and succumb. Secondary shock is the chief cause of death from burns, accounting for 80 per cent of the fatalities. Secondary shock is similar to that which follows other accidents and operations. It is particularly marked in second and third degree burns, in children, and in the aged, also when large areas of the skin of the trunk are involved. The anterior chest wall is striking in this respect, possibly due to a reflex inhibition of the heart and lungs, for fatalities often occur early after heat injuries of the thorax.

Secondary shock is due to several factors:

(1) *Untreated primary shock.* (2) *Lowered blood volume and blood-pressure.* The volume of circulating blood is diminished by extravasation of serum into the tissue spaces following the injury, resulting in a continuously low blood-pressure and concentration of circulating blood. The capillary wall may be rendered more permeable to plasma by the circulation of absorbed toxins. At first there is a fall in the systolic blood-pressure; later both the systolic and diastolic readings fall; and gradually records may become unobtainable, or the diastolic level may fall to zero. (3) *External loss of serum from the wound* occurs in the first twelve hours Superficial burns weep serum copiously, and it is estimated that this volume alone is sufficient to cause secondary shock. It is as exhausting as a hæmorrhage, and is greatest in third degree lesions. Estimation of the hæmoglobin shows that the blood is concentrated and may remain so for as long as sixty hours. (4) *Respiratory damage.* The inhalation and irritation of the respiratory tract by combustion gases is a contributory factor. Further, the shallow respiratory movements in shock, with the low blood-pressure, incompletely oxygenate the circulating blood, and, if prolonged, the important cerebral centres are irreparably harmed. (5) Wilson emphasises that the secondary shock is aggravated by *cold*, and especially mentions exposure during treatment, and the *trauma of cleansing*, factors which can both be easily eliminated with care

The estimation of secondary shock. There are two observations which assist the clinical impressions which *per se* tend to be erroneous. Blood-pressure readings are of great assistance in gauging the condition and progress of the patient, and will reveal, for instance, the sudden onset of delayed secondary shock or the spontaneous recovery from it. Estimations should be made hourly at first, then two-hourly, and later spaced out as the patient's condition dictates. The earliest sign of secondary shock is a lowered pulse pressure with or without a fall in systolic level. Pressures below 100 mm. Hg. or a rapid feeble pulse are serious. The records give positive indications for intravenous infusions. Determination of the hæmoglobin content of the blood is valuable, for it is frequently concentrated in severe burns, perhaps as much as 135 per cent. The immediate addition of fluid to the blood stream is required. In a severe case the hæmoglobin is calculated daily until it becomes normal. Persistence at a raised level requires the continuation of intravenous gum saline injections.

Toxæmia. This depends on the degree of the burn and on the nature and promptness of the treatment. With the present method of early tannic acid applications toxæmia is frequently eliminated or considerably modified. Children are more sensitive to toxæmia than adults, and this complication causes 10 to 15 per cent of the deaths from burns. The toxæmic stage begins 6 to 48 hours after the burn, and usually continues for about ten days, although occasionally it may last for three weeks. The secondary shock and the toxæmia sometimes merge

with fatal results in the 24–48 hour period. *The poisons are absorbed from the* injured area. They are at first liquefied burnt tissue, but after the third or fourth day bacterial products (particularly those of the hæmolytic streptococci) are superadded. It is noteworthy that extensive superficial burns, such as result from scalding or explosions, are followed by a much severer toxæmia than are those which penetrate deeply. An explanation of this may be that the large potential absorptive area—the subcuticular lymphatic and capillary system—is opened by diffuse but superficial burns. In some cases, the unfortunate victim suffers even further by the absorption of wound applications, such as picric acid, iodoform, or carbolic acid.

Wilson (*Edin. Med. Journ.*, 1935, XLII, 177) recently described his research on the toxæmia of burns. He produced the toxin by extracting fluid from the œdematous tissue adjacent to a burn. When injected into healthy animals it caused acute and often fatal toxæmia similar to that occurring after burns. The toxin was not present immediately after the infliction of burns, but took several hours to develop, thus corresponding with the time of onset of toxæmic symptoms —i.e., six hours. Bacteria were not always present in the extract, but if they were they augmented the toxicity of the experimental fluid. The delay before the *toxin appears suggests that it is elaborated by a vital process such as by autolysis* of the injured tissues. The nature of the toxin is not established; chemically it promises to be a higher protein derivative, and more than one noxious agent may be present. It contains an hepatic cell poison, a neurotoxic agent, and a depressor substance. Wilson considers that its effects are similar to those produced by peptone injections, and finds that when the toxæmia is fully developed it resists all known forms of treatment. He hopes that ultimately an effective antitoxin may be available.

Etiological factors in toxæmia. Wilson found that: (1) The blood chlorides *and the blood carbon dioxide combining powers are within the normal*; (2) the leucocyte count is normal; (3) the venous and capillary blood is not unduly concentrated; (4) little or no bacterial growth is at first obtained from the burns or from the patient's blood; (5) recovery may be spontaneous; (6) the administration of gum salines is followed by improvement; (7) saline infusions seem to aggravate the condition; and (8) in grave cases the blood-pressure suddenly falls.

Symptoms of acute toxæmia are: (1) The pulse-rate and respirations are accelerated. (2) Hyperpyrexia, 102° to 105° F., is constant and persistent. (3) The face is pale and cyanosed. (4) Vomiting is marked in a serious case. The vomit *may contain* blood from gastric erosions. Diarrhœa also occurs. (5) Patients are anxious, restless, and later delirious (in infants there may be general convulsions). *Drowsiness and apathy supervene.* (6) *The pupils are* dilated. (7) Coma and death may occur two to five days after the burn.

Sepsis—time of onset. Sepsis is evident about the fifth day, and is mainly due to the hæmolytic streptococcus which can be cultured from the wound but rarely from the blood stream. Septicæmia may appear about the ninth day and pass on to pyæmia; this is more likely after deep burns. The onset is frequently sudden, but may be insidious.

COMPLICATIONS OF BURNS

These are seen less frequently with efficient tannic acid treatment, but formerly they were common. They arise mainly during the period of septic

absorption The vital organs are affected most. *Delirium tremens* chiefly affects males who habitually take alcohol. *Toxic jaundice* may appear in the acute toxic stage—i e. before the fifth day—and is due to the destructive effect of the toxin on the liver. *Broncho-pneumonia* or sloughing of the mucous membrane of the trachea and bronchi occurs more particularly in the aged and in patients with burns on the chest; indeed, it is often the terminal factor. The inspiration of heated, irritating, or asphyxiating gas is frequently the causative agent, and death occurs about the fourth day. In the septic stage, *pulmonary emboli* arise and cause dyspnœa, blood-stained sputum, and pleural effusion. *Scarlet fever* in a mild form may develop after an incubation period of from three to four days The rash first appears about the wound, and then spreads to the rest of the body. The fauces are but slightly involved. At the same time, the suppuration in the wound usually increases, lymphangitis develops, and the lymphatic glands draining the part enlarge. This type of scarlet fever is not very infectious, and isolation, although desirable, is not strictly essential. *Acute nephritis* is manifested by blood and albumen (occasionally both) appearing in a scanty urine. It develops in association with scarlatina, and is probably due to the streptococcal toxæmia. *Vomiting or hæmatemesis* during burns suggests acute gastritis or duodenitis with erosion of the mucous membrane, and is an indication of the absorption of the bacterial or metabolic poisons. Erosions have been observed about the ampulla of Vater, which suggest the possibility of the toxin being excreted in the bile—a reasonable deduction, considering the severe liver damage in burns. *Perforation of the stomach or duodenum* has very occasionally occurred about the tenth or twelfth day after a burn. *Tetanus and gas gangrene* complicating burns have been reported. The infections are considered to arise from inoculation of the organisms at the accident, especially at outdoor fires—e.g. at factories, farms, hayricks, petrol explosions, and in aircraft crashes.

DEATH FROM BURNS

Immediate death may result from syncope or asphyxiation due to the products of combustion, chiefly carbon monoxide. *The most fatal period is towards the second twelve hours, when death results from severe secondary shock.* A patient may walk out of the cage of a mine or away from the scene of the accident, and yet collapse fatally a few hours later. During the first week death follows intense toxæmia, and may be precipitated by an acute pulmonary infection, especially after asphyxiation. In death from toxæmia, the liver changes are marked, the central cells of the hepatic lobules showing severe necrosis or fatty degeneration. To a lesser extent, the kidney and brain cells are similarly affected. The picture is of death from acute toxæmia of non-bacterial origin. Later, during the stage of exhaustion, an intercurrent infection may close the picture. The patient may die from general exhaustion or from the absorption of septic discharges. Occasionally the septic process and delayed repair drag on until amyloid changes appear in the vital organs. Patients in this weak state fall ready victims to influenza and intercurrent infections. Burns are more fatal than scalds, probably because the temperature of dry heat is so much higher and therefore more destructive. It may be 100° to 700° C., whilst that of boiling fluids is usually 60° to 120° C.

LOCAL EFFECTS OF BURNS

(1) *Detachment of epidermis.* Wilson considers that the epidermis is detached at the moment of contact with the heat, and before time has elapsed for blistering. In an explosion, the epidermis of the face separates readily, and similarly with the hands it is described as peeling off like a glove. Blisters take some time to develop and follow scalds—i.e. the comparatively lower degrees of heat. They are rarely seen after explosions—e.g. coal-mine explosions. He suggests that "underneath the very impervious stratum lucidum of the epidermis, gas and steam are suddenly developed in the application of heat, thus lifting the outer layers. This gaseous layer probably prevents to a considerable extent the subsequent deeper penetration of heat, just as, in the spheroidal state, a layer of steam prevents the heat of a red-hot metal from penetrating into a drop of water."

(2) *Stage of infection and separation of injured tissue.* This stage of the injury is that of inflammatory reaction, which ultimately separates the non-viable parts by granulation tissue. Unless the primary treatment is carefully instituted, the destruction is quickly extended by infection from the skin, clothing or dirt, or from the domestic greasy dressings so often applied. Burns of the buttocks are particularly liable to sepsis. The possibility of gas gangrene infection must be remembered in penetrating burns. General toxæmia is associated with the phase of suppuration in the wound

(3) *Stage of healing.* When the slough separates and the infection is overcome, a healing, granulating wound or an ulcer remains. Repair is often slow on account of the exhaustion and low level of health of the patient. Exuberant granulations develop, and unless the part is suitably splinted, excessive unsightly and contracting scarring is liable to follow. The part is splinted to keep the wound at its greatest dimensions, thereby checking the tendency to a contracted and movement-limiting scar. Thus a limb burned on the flexor surface if allowed to heal in flexion will seldom regain full extension until a plastic operation is performed. Burn cicatrices are notoriously unyielding and adherent to the deeper tissues.

TREATMENT OF BURNS

"Effective treatment must be undertaken as quickly as possible and every hour of delay counts heavily. In this respect it takes precedence of many abdominal emergency conditions." (*Medical Treatment of Men Burned in Colliery Explosions*, 1933, 5.)

Wilson urges the institution of "Burns" wards with a specially trained staff. The temperature of these wards should be amply raised, for many of the patients are considerably exposed during the tannic acid treatment. Mitchiner at St. Thomas' Hospital found the mortality and duration of illness considerably reduced when all burns were under unified control.

First-Aid Treatment

(1) *Burning.* Flames are extinguished by throwing the person down, rolling him on the floor and wrapping him with a coat, blanket, rug or sacking, and by the judicious application of water. The terrorised attempts of the patient to rush into the open air must be resisted, for this merely fans the flame.

(2) *Asphyxiation.* Artificial respiration is performed until regular breathing

returns and the pulse is palpable. When available, these efforts are supplemented with inhalations of oxygen and 6 per cent carbon dioxide.

(3) *Dressing* A compress of tannic acid is applied to the affected area; a ready homely remedy is a handkerchief soaked in strong cold tea or a compress of tea-leaves. Failing this, a compress wrung out dry with 1 per cent aqueous picric acid is applied *Under no circumstances should flour, carron oil, or other greasy substance be used.* These preparations are ineffective and septic, and render the application of tannic acid difficult, time-consuming, and shock-producing.

(4) *Stimulant* If the patient can swallow, a cup of hot tea, coffee or lemonade, sweetened and containing one teaspoonful of brandy, is given.

(5) *Transport* Should the patient be in the open and the weather cold, the body warmth is preserved by removal to suitable surroundings, and rugs are applied Patients *must* be carried, as they have probably inhaled carbon monoxide which has a weakening effect on the heart. When a journey in a vehicle is necessary the patient is well wrapped in blankets, and hot-water bottles are judiciously placed near the body if the subject is conscious. Most ambulances are fitted with oxygen cylinders and inhalations are given steadily.

(6) *Pain* A full dose of morphia with a cardiac tonic, e g. coramine 1 cc., is given to relieve the pain This sedative checks the development of secondary shock and acts as a pre-anæsthetic in readiness for the cleansing of the burn which must shortly follow

(7) *Associated injuries*, e g. fractures, grosser wounds, etc., are suitably treated.

Treatment of Asphyxiation

Asphyxiation is not an infrequent complication of burns, and is usually due to the inhalation of hot gas or carbon monoxide. Carbon monoxide has a much greater affinity for hæmoglobin than has oxygen, and a stable compound results which is broken down with difficulty The patient is rapidly rendered weak and helpless, for as the carbon monoxide is inhaled, the oxygen combining power of the hæmoglobin is reduced. Fresh air, oxygen and carbon dioxide, warmth and rest are required, fresh air to arrest the poisonous intake, oxygen to ensure a full supply to the uncombined hæmoglobin in the blood, warmth to maintain life, and rest to reduce to a minimum the body needs for oxygen. Carbon dioxide 6 per cent will stimulate the flagging respiratory centre, increasing the depth and rate of inspiration. The inhalation of pure oxygen for long periods is necessary to preserve life and is given through a closely fitting face mask. It is possible that if the oxygen is in sufficient concentration some of the carbon monoxide may be displaced from the hæmoglobin.

Complications are anticipated by the use of a *steam tent* or of an *oxygen chamber* as advised for pneumonia Frequent administrations of oxygen and carbon dioxide are given until the respiratory rhythm is easy and approaching normal, and the colour good

Treatment of Shock

(1) *General care and fluids* As shock is a frequent cause of death after burns, treatment to avoid and to relieve it is immediately instituted. The natural tendency is to spontaneous recovery from shock. The patient, without being undressed, is put to bed, the foot of which is raised; drinks are given if he is able to swallow, but failing this, rectal salines are administered, while for the more severe cases gum salines, continuous drip salines or blood-transfusions are advised.

(2) *Dressings.* Whilst dealing with the general condition it is important to remember that the local condition is the primary aggravating factor, and attention must be quickly directed to the injuries and burns. Delay whilst "treating the shock" is harmful. Compresses soaked in fresh 2 to 3 per cent tannic acid are applied; this coagulates the burnt tissue, arrests the loss of serum, checks the absorption of toxins, and relieves the pain—a vital factor in the prevention of shock.

(3) *Intravenous 6 per cent gum saline.* Wilson states that the secondary shock can be prevented or relieved by the prompt infusion of a colloidal solution. He finds it preferable to blood-transfusions, and considers that ordinary saline is useless or even harmful. He advises 600 to 1000 cc. of gum saline slowly introduced. If the blood-pressure is at or near the normal level after twenty-four hours, nothing is to be feared from secondary shock.

(4) *Oxygen and carbon dioxide inhalation.* The continuous administration of oxygen and carbon dioxide increases the depth of the respirations, and thereby assists in raising and maintaining the blood-pressure.

(5) *Sedative.* An adequate sedative is given immediately. A pre-anæsthetic of morphia or omnopon and scopolamine frequently eliminates the necessity for an anæsthetic later, and the wound can be treated under the morphia effect only. The author has found Mitchiner's Dosage Table valuable. Copies can usefully be carried in a note-book or hung up in the Casualty Department.

DOSE OF SEDATIVE PREPARATORY TO CLEANSING (MITCHINER)

Children.		Adults.	
Age.	Preparation.	Age.	Preparation.
1 month	Tinct. camph. co. m. ii-iii	12-15 years	Tinct. opii. m. xxx or inj. morph. gr. $\frac{1}{6}$
2 months	Tinct. camph. co. m. iv-vi		
3 months	Tinct. opii. m. $\frac{1}{4}$-$\frac{1}{3}$	15-20 years	Tinct. opii. m. xxx or inj. morph. gr. $\frac{1}{4}$
6 months	Tinct. opii m. $\frac{1}{2}$-$\frac{3}{4}$		
1 year	Tinct. opii. m. ii-iii or inj. morph. gr. $\frac{1}{75}$	Over 20 years (women)	Tinct. opii. m. xxx or inj. morph. gr. $\frac{1}{4}$-$\frac{1}{3}$
Over 1 year	Tinct. opii. m. ii for each year and m ii in 15 min. if necessary or inj. morph. gr $\frac{1}{75}$ for each year.	Over 20 years (men)	Tinct. opii. m. xxx or inj. morph. gr. $\frac{1}{3}$-$\frac{1}{2}$.

Note.—Atropine sulphate $\frac{1}{200}$ *to* $\frac{1}{100}$ *gr. or coramine 1 cc. is given for slow* or shallow breathing. Tinct. opii. is more satisfactory than morphia.

(6) *Prophylactic sera.* When injuries and burns have been sustained out of doors, e.g. a hayrick fire, an ignited motor vehicle, an aeroplane crash, or war explosion, there is the danger of tetanus and gas gangrene, and prophylactic anti-sera should be given early.

(7) *Diet.* The diet in cases of burns for the first two weeks is important. It is dictated by the intense congestion, degeneration and necrosis of the liver which develops within a few hours of the injury, thus rendering the organ incapable of dealing with other than the simplest food. The diet should consist of water, flavoured with lemon or orange juice and generously sweetened with glucose, until the temperature and pulse have been normal for twenty-four hours.

Deviation from the schedule, even to milk, will often cause a rise in temperature. Patients will exist comfortably on this diet for two to three weeks.

Treatment of the Burnt Areas

(1) *First degree* First degree burns are usually due to sunburn or to scorching by heat, gases, or steam. They are quickly relieved by compresses or frequent applications of lead lotion, spirit, sodium bicarbonate solution 5 per cent, or hypertonic salines. Hazeline cream or lanoline is of assistance later. Further exposure to the sun and other heat is avoided for a period.

(2) *Burns other than first degree.* As soon as the patient's condition permits, the surgeon cleanses the wound thoroughly, and applies some form of surface coagulant, nowadays chiefly tannic acid. The *débridement* is carried out when the sedative has taken effect and the blood-pressure is rising. Victims are frequently entirely blackened by dust, smoke and soot, giving the impression that the injuries are extensive; this especially applies to explosions in coal mines. If required, gas with oxygen and carbon dioxide is the anæsthetic of choice, and failing this, ether with oxygen and carbon dioxide.

Cleansing the burns. Small areas at a time are dealt with; this avoids unnecessary chilling, and therefore shock. The essentials of the operation are:

(a) The utmost thoroughness in removing every scrap of epithelium to the entire limits of the lesions.

(b) Caressing gentleness in wiping and in the removal of damaged skin. Therefore, scrubbing the part heavily with gauze, lint or a scrubbing brush (cardinal sins in any open wound as they cause severe pain) are prohibited in shocked and exhausted burnt patients. Again, they call for a deeper degree of anæsthesia—a further objection. Blistered skin and devitalised tissue is removed by wiping with gauze moistened with saline, which is sufficient to remove epidermis.

(c) Strong antiseptics, e g. mercurials and carbolic acid, are avoided; ether and alcohol are used only when grease is present, and then sparingly.

TANNIC ACID TREATMENT OF BURNS

The treatment of burns by a weak aqueous solution of tannic acid was first advised by Davidson in 1925. A report on its effect was made at Edinburgh in 1927; since then, many papers confirming its value have been published. (Wilson, *Med. Res Counc.*, No. 141, 1929; *Pract.*, 1936, CXXXVI, 394; and *Edin. Med. Journ*, 1935, XLII, 177; Mitchiner, *Lancet*, 1933, I, 233.)

The rationale of the method is that, after cleansing the wound, a fresh aqueous solution varying from 2 to 25 per cent, but usually 2 to 3 per cent, tannic acid is applied to the burnt area; on drying, a black or dark brown coagulum remains.

The action of tannic acid is: coagulation of the burnt tissue, thus reducing pain and arresting the loss of serum, the latter minimising dehydration, the fall of blood-pressure and shock. By coagulating the tissues the absorption of liquefied damaged cells is prevented, thus diminishing toxæmia. The usual infective process and general exhaustion are reduced by prompt and efficient coagulation. The part is effectively splinted. Rapid healing frequently follows. If the burn is superficial, recovery usually follows in ten to sixteen days with a

supple and inconspicuous scar. If the burn is deep, the coagulum will separate in about fourteen days, leaving a freely granulating area covered by pus.

The Solution of Tannic Acid.

Fresh aqueous tannic acid solution must always be used, for it becomes mouldy and useless on storing or gradually hydrolysed into gallic acid and pyrogallol (indicated by a dark colour). The addition of perchloride of mercury, making the solution 1 in 1500, checks the mildew formation, but the mercury slowly decomposes and the tannic acid becomes "dead" in two months. A fresh preparation is advisable for each case, and it is best stored in a powder consisting of tannic acid 15 grs., with perchloride of mercury 1½ grs. This is dissolved in four ounces of distilled water, making a 2½ per cent solution, which will keep during the course of treatment of a patient. Tannic solutions over 1 per cent form a

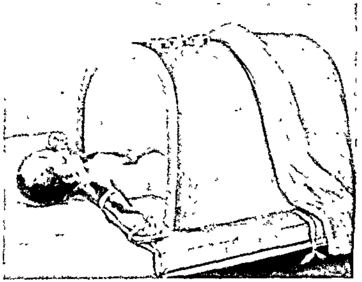


Fig. 2943.—Multiple scalds. Applying radiant heat after tanning the affected areas. "Crucified" position.

tough surface coagulation which prevents further penetration and so limits the coagulation, and for this reason the stronger solutions are not always advisable.

The Application of Tannic Acid.

The tannic is applied by a spray or compress, and is then dried. On the trunk and limbs either method of application is satisfactory, but the compress is more easily arranged. Tannic acid has no effect on healthy skin, but is irritating to mucous membranes; therefore, during the application the eyes, nostrils and mouth are protected by small pads wrung out in saline or sodium bicarbonate solution. The usual method of drying is by an electric cradle over the affected part (fig. 2943), by encirclement with hot-water bottles, or by gently applying a hair-drying apparatus. The evaporation must not be conducted too vigorously, or otherwise the penetrating power of the acid is arrested and a poor coagulum forms, or the patient may be overheated and stifled, causing restlessness and sweating, which are harmful generally to the burnt area and to the coagulation process. Arrangements are made to maintain the body warmth and to avoid chilling during the necessary exposure of the patient while the tannic solution is drying. When a spray is used, the acid is applied from a sterile glass atomiser. It is alternately sprayed and dried every half-hour for three hours or more until a firm black coagulum results, and after that three- to four-hourly for twenty-four

hours. *This method is satisfactory for lesions* of the face and of the perineum where dressings are difficult to retain in position, but it is not so quick as a compress and calls for more attention. Its use is not advisable except in hospital, in a nursing home, or in the patient's own home when operated by a skilled person.

The tannic acid is reinforced by several further applications during the second twenty-four hours. The coagulum becomes adherent and remains in position for 7–21 days, when in satisfactory cases it flakes off, revealing as a rule a healed or granulating area. *For success dryness throughout is essential.*

The part is carefully splinted in the position of maximum extension, so as to ensure that the coagulum forms over the largest affected surface and thereby avoids crinkling and later cracking (fig. 2944). After four or five days the coagulum contracts

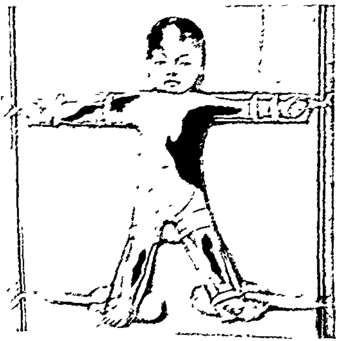


Fig. 2944.—Multiple scalds.

Note:

(1) The splinted legs are also tied to the bedside, to avoid their rubbing against one another.

(2) The pad to soak up urine and thus avoid wetting the coagulum.

Later Applications for Burns—Ointments.

Ointments are useful for partially healed areas after the tannic crust has separated. They are applied on sterile lint:

(1) Calamine 30 grs.
Zinc oxide 30 grs.
Oil of terebene 15 minims.
Vaseline 1 ounce.

(2) *Wilson's Ointment:*
Zinc oxide 2 drachms.
Oil of eucalyptus 1 drachm.
Vaseline 1 ounce.

Cases of Multiple Burns.

Treatment with 20 per cent tannic acid. When several patients require treatment, as in war-time casualties or in a mine explosion, it is not possible, owing to shortage of staff, etc., to spray patients with the weak solution every two hours.

A B

Fig. 2915.—A case of severe burns. (A) Immediately after treatment by tannic acid, and (B) ten days later. ("*Practitioner.*")

Tannic acid 20 per cent in acriflavine 1 in 1000 is the preparation which best meets the situation; one application is usually sufficient, although occasionally a second painting or spraying is required (fig. 2915).

The Home Treatment of Burns by Tannic Acid

For the minor burns and scalds occurring in the course of domestic life, the tannic acid compress and spray are unsatisfactory when used by patients in their homes, for these procedures are rather messy and require some degree of intelligence for their effective application. Further, the doctor cannot attend frequently to use the spray, nor is it always advisable to leave it in the hands of the patients and their relatives.

(1) *Tannic acid 20 per cent.* Wilson's solution (tannic acid 20 per cent in 1 in 1000 acriflavine) is efficient and convenient. After the careful preliminary toilet has been carried out, the above lotion is *painted* on the area with a sterile brush and is thoroughly dried. The applications are continued until a dark mahogany colour is produced; 2–3 coats are usually required. This treatment can be safely per-

hours. This method is satisfactory for lesions of the face and of the perineum where dressings are difficult to retain in position, but it is not so quick as a compress, and calls for more attention. Its use is not advisable except in hospital, in a nursing home, or in the patient's own home when operated by a skilled person.

The tannic acid is reinforced by several further applications during the second twenty-four hours. The coagulum becomes adherent and remains in position for 7–21 days, when in satisfactory cases it flakes off, revealing as a rule a healed or granulating area. *For success, dryness throughout is essential.*

The part is carefully splinted in the position of maximum extension, so as to ensure that the coagulum forms over the largest affected surface and thereby avoids crinkling and later cracking (fig. 2944). After four or five days the coagulum contracts

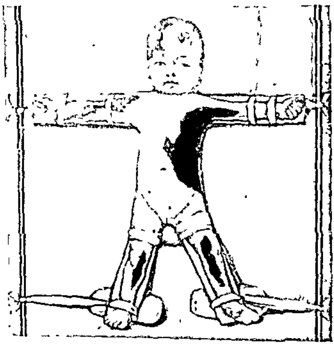


Fig. 2944.—Multiple scalds.
Note.
(1) The splinted legs are also tied to the bedside, to avoid their rubbing against one another.
(2) The pad to soak up urine and thus avoid wetting the coagulum.

and retracts from the edge of the burn—an undesirable process which is aggra by movement, by moisture or by lying on the part. These factors are detail that they may be avoided, for a break in the surface allows the access of bac to the wound. Breaking off pieces of the crust is an attractive pastime to patients, especially children). Adults are warned to leave it strictly alone, suitable restraint of the hands and feet prevents children from interf with it

Burns of first, second or third degree show gratifying results—a layer of r pink epithelium is revealed as the crust is shed. Deeper burns heal more slo and as separation is delayed, suppuration is more probable. When the coag is detached, severe burns are treated by sterile vaseline or ointment pad plaster-of-Paris case is helpful. When the area is superficial, a successio elastoplast bandages assists epithelialisation. Pinch or Thiersch grafts re the period of healing.

burn and admitting sepsis. In a circumferential crust, the contraction acts like a tourniquet on the limb, e.g. a finger or the wrist, causing œdema and exudation, later, wasting of the part from ischaemia, and occasionally even gangrene. In these cases the coagulum is split down the sides and a piece of 1 in 1000 acriflavine gauze is laid along the resulting fissure.

(6) *Soiling.* Contamination of the affected areas by food, drink, saliva, mouth-washes, tears, urine, fæces, and toilet water is sedulously avoided (fig. 2916).

(7) *Insomnia.* Insomnia is experienced by some patients due to the discomfort and constriction of the crusts; suitable sedatives (avoiding opium) are given, for sleep is essential to maintain the general health and the steady repair of the burn.

(8) *Further blisters.* If further blisters and pustules develop, they are opened, sponged, and tanned.

Essentials of Tannic Acid Treatment Summarised

(1) Thorough preliminary cleansing.

(2) Early application of freshly-made $2\frac{1}{2}$ per cent tannic acid, continued repeatedly for twenty-four hours.

(3) Thorough drying. Waterproof dressings are unnecessary and harmful *Under no circumstances should the coagulum be allowed to become wet.*

(4) Moist dressings and hot fomentations, whether antiseptic or otherwise, *must on no account be applied.*

Criticisms of the Tannic Acid Method

Turner (*B.M.J.*, 1935, II, 995) offers the following criticisms of the tannic acid treatment of burns, basing his remarks on a five-year experience of the tannic method, and a one-year period with a modified *mercurochrome technique.* During the six years he had the large experience of 2,696 incapacitating burns. His observations therefore demand attention:

(1) *The tannic acid coagulum* It is coarse, tough, and non-transparent, so that pus forming beneath it is difficult to detect and may spread over a large area before becoming apparent or perforating the crust, and thereby destroy the young *epithelium. When the scab is removed from such a bed of pus, a coarse granulation* tissue remains, which heals slowly and tends to produce gross scarring. Turner considers that this difficulty can be overcome by the use of a thin transparent scab, such as that produced by mercurochrome.

(2) *The corrosive action of tannic acid.* Tannic acid stains and is destructive to clothing and bed linen, which rots after a few visits to the laundry. Mackintoshes are necessary to protect the bed, and these act on the burnt area like a fomentation, delaying evaporation and so interfering with an essential of the tannic treatment, i.e. free evaporation and the preservation of dry crusts.

(3) *The chemical instability of tannic acid.* Tannic acid is rapidly unstable in aqueous solution, although certain antiseptics do prolong its useful life.

MERCUROCHROME TREATMENT OF BURNS

After trial with several drugs, Turner decided on a 2 per cent aqueous solution of mercurochrome. He has experienced encouraging, rapid, and reliable results, and claims the following advantages for it:

"(1) It does not precipitate protein, thus it will penetrate the devitalised

burnt tissue. (2) It is an effective antiseptic in the presence of protein, thus it will inhibit the development of infection. (3) It forms a crust on drying which is thin and transparent. (4) It does not irritate the tissues. (5) A 2 per cent aqueous solution is permanently stable. (6) Healing progresses steadily under the scab. (7) Pain and discomfort are no more than by other methods. (8) It does not destroy the bed linen."

Technique of the mercurochrome treatment. Mercurochrome is applied in the same way as tannic acid, the preliminary opium sedative being given (see page 5449), after which the cleansing is carried out.

(1) The affected parts are swabbed with 2 per cent aqueous mercurochrome and then dried.

(2) The mercurochrome is reapplied as follows: 1st day—6 hourly; 2nd day—3 times a day; 3rd day and subsequently—twice daily.

(3) Careful drying is performed after each application, the area then being exposed to the atmosphere.

(4) Where a large area is involved and the patient has to lie on part of the burnt area, a portion of the crust may be spoiled unless absolute dryness is maintained. Frequent turning and free ventilation around the patient avoid this possibility Mackintoshes under the sheet are avoided if possible.

Pus collecting under the mercurochrome crust is readily detected through the thin and semi-transparent film, and is evacuated by snipping the covering away from over and around the affected part, swabbing with normal saline, and re-applying the mercurochrome as before.

In Turner's experience no toxic effects have followed the use of this drug.

PICRIC ACID TREATMENT OF BURNS

The application of a 1 per cent aqueous solution of picric acid every 24–48 hours was widely used before and during the War. It had the virtue of relieving pain quickly, of coagulating the superficial tissue, and of stimulating healing. Scarring, however, was considerable. Picric acid has no penetrating power, and unless the preliminary cleansing is thorough and early, infection and sepsis develop under the crust There were other disadvantages: certain subjects had an idiosyncrasy to the drug, and the application was followed by persistent dermatitis irregularly on the rest of the body. Again, when large surfaces were involved, the picric acid was absorbed from the dressings, and children especially were susceptible to poisoning by it, becoming greyish-yellow in colour, with yellow vision, apathetic, dazed, and ultimately comatose. The urine was tinted yellow or red and contained albumen.

The danger of poisoning following the picric acid treatment of burns is known to coroners who occasionally ask pertinent questions concerning the observance of the precautions necessary when this drug is used.

The mortality from burns treated by picric acid is twice that which follows treatment by the tannic acid method.

PARAFFIN TREATMENT OF BURNS, INCLUDING AMBRINE

Following the picric acid therapy, towards the end of the War and for several years afterwards there was a phase of painting burns with melted paraffin

accidents, and the features may be destroyed and the patient rendered unrecognisable.

The hair is clipped and shaved, leaving a clear wide margin around the lesion. With protecting pads of moist saline gauze over the eyes and nostrils and inside the mouth, the face is sprayed with tannic acid or mercurochrome as already detailed. Adults are warned not to touch it, and children's hands are tied. Feeding is by fluids through a tube and funnel, supplemented by intravenous infusions, etc.

Eye. The eye may be burnt by hot metal or fluid, or by a corrosive. The danger is twofold: first, when the cornea is injured the globe may become adherent to the eyelid (symblepharon), or the eyelids may adhere to each other (ankyloblepharon). The injury is treated on the same lines as a conjunctival or corneal injury or ulcer. The frequent introduction of warm sterile vaseline will prevent fusion of the eyelids or organisation with the cornea. Law advises passing a smooth glass rod under the eyelids to the limits of the conjunctival folds twice daily to avoid adhesions.

Neck. Severe burns of the neck are quickly followed by tracheitis, bronchitis, or broncho-pneumonia. The neck is difficult to fix during the coagulation, but the process can be assisted by securing a padded back splint with a foot-piece, or by a plaster-of-Paris case to the forehead and round the chest. The tannic acid is applied with the neck turned so that the burn is stretched to its largest area, thus instituting conditions for healing without deformity by torticollis. The nose and the mucous membrane of the mouth are protected. If they are affected, frequent irrigations with bicarbonate of soda or slightly hypertonic solutions of saline and sodium sulphate 2 per cent are made, with the addition of adrenalin or ephedrine.

Upper Limb and Shoulder. Burns of the *upper surface of the shoulder* are nursed with the arms down to the sides, whilst for the axilla the arms are placed in the policeman "stop" position or in the "crucified" posture, thus avoiding

Fig. 2347.—Burns of the hand treated by tannic acid.
Note the pads between the fingers to avoid healing (and fixation) in adduction.

the fixation of the arms to the side by scarring. The coagula of circumferential burns of the *arm* are split at the *sides, allowed to gape, and then cautiously re-tanned* by the weak solution. Alternatively, a piece of flavine gauze is laid over the gap to avoid infection. The separation allows swelling of the limb and avoids interference with the venous and lymph circulations.

When *the anterior or flexor surface of the forearm* is affected, the arm is splinted in extension, and if the posterior or extensor area is damaged, the arm is splinted in the flexed position. If both surfaces of the arm and forearm are burned, splinting in extension to 135 degrees is probably best, with the hand in semi-supination

Fingers call for care in three respects :

(*a*) The tannic acid applied is only $1\frac{1}{4}$ per cent. Each application is a spare one in *order to avoid a thick unyielding crust which would contract and impair* the blood supply to the tips, and be followed by atrophy or even occasionally by gangrene of the pulp of the fingers.

(*b*) Before application of the tannic, the fingers are splinted in full abduction ; *small pads of wool, a bandage, or corks pressed in between the webs* are satisfactory for this. Limitation of movement by scarring and contraction is thereby minimised (fig. 2917).

(*c*) A splint is applied to keep them in a position of flexion or extension according to the surface chiefly burned. A silkworm-gut suture through *the end of the finger is useful to fix the parts in extension or flexion* as required.

Trunk and Thighs. Burns of the *abdomen and front of the thigh* are nursed with the patient lying supine under a cradle The pressure points are treated frequently, and the patient lies on the sides for relief.

Burns of the *back and posterior surface of the thigh are treated with the patient* lying on the face. This prone position is quite comfortable and is satisfactory for sleeping, the head being turned to one side, and pillows being unnecessary.

Perineum and Buttocks. Burns about the buttocks and perineum are complicated by two factors :

(*a*) The presence of infection (*especially of gas organisms) from the anus and* genitals.

(*b*) The difficulty in the toilet, nursing, and application of dressings.

A painstaking *débridement* is necessary. A child is slung by the feet into the "gallows" position (as for a fractured femur) or splinted as shown in figure 2911 ; these procedures simplify nursing, and the excretions are easily *controlled and collected.*

An adult is treated on the face with the legs abducted by bandaging the ankles to the corners of the bed. The tannic acid is sprayed on, as compresses are difficult to retain in position.

Micturition and defæcation are satisfactorily managed by the use of small receptacles and protecting pads of dry wool. An enema on alternate days immediately after breakfast ensures an action and minimises the soiling, although the patient on fluid diet for the first 7–10 *days has no bowel action, and no ill-effects follow such a period of constipation.*

The anterior pressure points are protected, and treated frequently to avoid sores.

CHAPTER VI

Peri-anal Suppuration

Peri-anal suppuration is a frequent occurrence, and detailed attention to diagnosis and treatment is necessary in order to secure prompt healing and to avoid a residual fistula-in-ano (see also Vol. I, page 1327).

Peri-anal suppuration may be classified as follows:

(1) Peri-anal boil or abscess.
(2) Submucous abscess.
(3) Ischio-rectal abscess.
(4) Pelvi-rectal abscess.

Peri-anal Boil or Abscess

Peri-anal boil or abscess is a frequent condition which arises in association with chronic avitaminosis, pruritus ani, worms, etc. It develops by infection of a hair follicle or sebaceous gland, and is in no way different from boils in other parts of the body. It causes considerable inconvenience, pain, and malaise. A responsibility of the practitioner conducting its treatment is to exclude a connection with the rectum or anal canal by carefully palpating these areas with a finger in the rectum, especially seeking a track of induration, or perhaps tenderness connecting the two. A rectal speculum is inserted and may reveal a fissure-in-ano, occasionally a foreign body such as a fish-bone, rarely a fistula, and still more rarely a track from which a bead of pus can be expressed.

The association with the alimentary canal excluded, the boil is treated on general lines. As the boils tend to appear in crops, no half-measures, either local or general, are permissible or effective. The patient must stay in bed, and hypertonic compresses are persisted in throughout. The bowels are opened on alternate days after a turpentine enema, and if a wound is present, it is first protected by gauze thickly plastered with sterile vaseline. Incision is rarely required, but if the skin over the abscess appears unyielding, there is danger of spread into the ischio-rectal fossa, in which case an anæsthetic is given and a crucial incision is made on the lines to be described for the treatment of ischio-rectal abscess. Wide excision of the skin edges is unnecessary.

Submucous Abscess

The submucous abscess may be a superficial collection of pus secondary to an abrasion, but, as in the case of the peri-anal boil, the danger is that it is secondary to an ischio-rectal abscess or that, if untreated, it may track between the sphincters and infect the fossa.

Ischio rectal Abscess

The ischic-rectal abscess is a collection of pus in the ischio-rectal fossa proper, and is a much more serious condition than a peri-anal boil because it is frequently

connected with the rectum or anal canal; the somewhat difficult subject of fistula-in-ano is also concerned (see also Vol. 1, page 1327). It is usually acute, occasionally sub-acute, and may be chronic, when it is associated with a fistula-in-ano or is possibly tuberculous.

The infection is usually a mixed one containing staphylococci, streptococci, B. coli or other organisms. The smell of the pus is a prominent feature; it suggests infection with gas-forming organisms which enter from the bowel. In this event the spread may be rapid and tissue destruction considerable, including the surrounding skin and the mucous membrane of the anal canal.

An ischio-rectal abscess must be treated with great care because:

(1) It may track posteriorly or anteriorly and infect the other side, or may extend forwards causing suppuration behind the pubis.

(2) It may rupture into the rectum, draining incompletely, and a direct internal fistula be formed. If the abscess is inadequately treated, an external or complete fistula may remain, and further abscesses arise later.

Pelvi-rectal Abscess

The pelvi-rectal abscess is fortunately uncommon, but the prognosis is serious and cure is difficult or unlikely. The pus collects in the true pelvis, perforates the levator ani muscle, and slowly accumulates in the ischio-rectal fossa, finally presenting externally around the anus or bulging into the rectum. The infection is usually sub-acute or chronic, and not infrequently tuberculous.

SIGNS AND SYMPTOMS OF SUPPURATION ABOUT THE ANUS

Suppuration about the anus causes general malaise and pyrexia. Locally, pain, tenesmus and throbbing are experienced, while later redness, swelling, induration, fluctuation, and a purulent discharge appear. The swelling, which is not at first obvious, may present to one side of the anus or may bulge largely into the anal canal. In the early stage, diagnosis is doubtful, and a combined examination, consisting of external palpation and a finger in the rectum should never be omitted. Both sides are carefully compared and a deep abscess is often detected, but possibly only after a second or third examination. In a well-nourished person, the prominence of the bulging abscess is not immediately apparent, and the redness may be only a slight blush. The anal canal is inspected through an illuminated rectal speculum.

TREATMENT OF SUPPURATION ABOUT THE ANUS

Where an ischio-rectal or submucous abscess is diagnosed, the treatment is by drainage; aspiration or delay for spontaneous rupture is ineffective.

Home or out-patient treatment is not permissible, and these patients should be admitted to a nursing home or hospital.

Operation for Ischio-rectal Abscess

The patient is placed in the lithotomy position. If the abscess has ruptured, then a probe is cautiously inserted and the connection or otherwise of the abscess with the rectum is determined. A finger in the anal canal palpates the tip of the probe, and clear evidence of the relation of the abscess-cavity with the bowel is

available. A fissure-in-ano, a fistula, a foreign body or an ulcer may be found. A bead of pus may be seen exuding from an opening in the mucous membrane about the valves of Morgagni, especially if assisted by pressure on the abscess. In the event of this direct communication at the level of or internal to these valves, a second operation will be required since primary division of the external sphincter is inadvisable.

In treating the abscess the surgeon aims at incising the cavity so that it is converted into a comparatively shallow ulcer. Thus drainage is ensured and healing follows circumferentially whilst the floor elevates, and a residual fistula-in-ano is prevented. Injury to the sphincters is carefully avoided.

The primary incision is begun just outside the anal margin and radiates outwards, passing over the estimated centre of the abscess (fig. 2948). When the pus is superficial it is readily found, but in some cases it is deep and requires seeking; in this case artery forceps are inserted through the fat in the most likely direction,

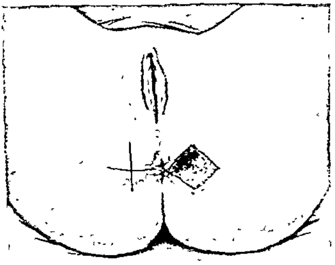


Fig 2948.—OPERATION FOR ISCHIO-RECTAL ABSCESS.

On the right side the lines of incision into the abscess are shown On the left side the four flaps have been excised, leaving a large quadrilateral area. A stout silk ligature has been passed from the abscess-cavity through the fistulous tract into the rectum and tied lightly.

and the blades are opened in north and south, and east and west planes. The abscess-cavity located, the opening is much enlarged by the scissors, working in the line of the incision, but avoiding the region of the external sphincter and the rectum Wide extension on to the buttock so that the cavity is rendered comparatively shallow is the object The pus is wiped away and a hot pack is inserted into the cavity to check the hæmorrhage The entire extent of the abscess is now visible. Loculi are opened by a gentle and intelligently directed finger. A small track leading into the rectum or passing through the levator ani muscle into the pelvis proper may sometimes be detected. In the former case nothing is done at first beyond passing a stout black silk suture through the opening and out through the anal canal, and loosely tying the ends When the abscess penetrates the levator ani muscle it is carefully defined and dilated in the direction of the muscle-fibres. The pus is sucked out or irrigated with pure eusol, and a tube is inserted through the muscular opening

In all cases a specimen of the pus is sent for bacteriological examination.

In cases of ischio-rectal abscess, in order to secure drainage and healing, the

surgeon must incise through uninflamed tissues. The cavity, frequently a deep one, is converted into a large but shallow wound; *extensive incisions achieve this.* The radiating cut is continued outwards on to the buttock, another incision intersects it at right angles through its middle, and the corners are cut off. The division of the skin near the anus is continued cautiously to its junction with the mucous membrane. The external sphincter, which extends to just within the anal canal at the level of the anal valves, must be visualised.

To the uninitiated in rectal surgery, this treatment may appear unnecessarily radical, but experience shows that nothing short of it is consistently followed by healing.

The bleeding points are controlled by hot compresses, pressure, and torsion with artery forceps. If ligature is required, then the finest plain catgut is used, or the bleeding points may be tied with silk, the ends of which are left very long so that they can be withdrawn at a later stage. At the end of the operation, the sphincter is cautiously stretched to admit three fingers.

A *bilateral abscess* may be manifest clinically or may only be discovered whilst dealing with the first. Both are treated in exactly the same manner, and no modification of the radical incisions is made The temptation to try a smaller opening must be resisted, as otherwise it will be found that the lesser abscess heals more slowly than the larger one. There may be a communicating tract either behind or anterior to the anus, in which case the tract must be laid widely open.

Gas formation is a serious complication of an ischio-rectal abscess; it is associated with severe toxæmia, whilst the swelling and redness are more marked and widespread than with the average suppuration in this area. There is considerable necrosis of the subcutaneous tissues. Prompt incisions are made on the radical lines already described, and care is taken to render the patient fit for operation by a preliminary intravenous infusion of saline and glucose. No hesitation need be felt in excising the skin flaps.

Ischio-Rectal Abscess communicating with the Anal Canal or Rectum

As already mentioned, no attempt is made at the first operation to deal with a track passing from an ischio-rectal abscess into the anal canal. The external drainage arranged, two weeks later a second operation is undertaken. The practice is based on the premise that during this time the external sphincter has become fixed by inflammatory induration, and that therefore when it is divided its cut ends cannot retract and incontinence will not follow. The insertion of the thick silk ligature already mentioned, besides acting as a guide for the second operation, by its irritation also stimulates inflammatory reaction and the fixation of the sphincter.

The second operation. The anus is gently stretched, a speculum is inserted into the rectum, and the internal opening is defined by probing cautiously through the abscess wound or by passing a grooved probe director along the ligature. The intervening tissue between the exterior and the probe is completely incised so that the anal canal and the abscess wound are continuous. The edges are trimmed slightly if necessary, and the daily dressing is continued, taking care to pack a small strip of gauze into the anal canal.

Tuberculous Ischio-Rectal Abscesses

Tuberculosis of the anus is rare, and is usually met with as a fistula-in-ano. The bacilli become located in the anal region by one of the classical routes: (1) By a blood-stream infection; (2) by internal trans-lumenal infection, usually from tuberculous enteritis or from swallowed tuberculous sputum; or (3) by direct spread from genito-urinary tuberculosis or from spinal caries, or from infection of the sacro-iliac or hip joints

Treatment consists in wide excision of the infected area with a diathermy knife. light treatment, and attention to the primary focus and, later, transfer of the patient to a country or seaside sanatorium.

Submucous Abscesses

Submucous abscesses are opened on the same principle as the externally presenting abscess. A preliminary stretching of the sphincter improves the exposure of the part. The mucous membrane only is cautiously incised by a longitudinal incision, and the redundant part is snipped away in order to afford ample drainage. A tube wrapped in sterile vaseline-gauze is inserted into the rectum.

The submucous abscess may be a manifestation of an infected intramuscular lymph gland or of an undetected ischio-rectal abscess pointing internally, usually between the internal and external sphincters. In such a case, external drainage is arranged as previously detailed, and a stout silk ligature is inserted through the track from the anal canal to the abscess-cavity, and is loosely tied on the exterior; it is a guide to the second operation ten to fourteen days later when the external sphincter is divided in order to obtain healing from within outwards.

AFTER-TREATMENT OF PERI-ANAL SUPPURATION

The general health is maintained by warmth, an adequate supply of fluids, and nine to ten hours sleep. Nursing in an airy room or (weather permitting) in the open air is an advantage The diet consists of fresh fruits, vegetables, and fats, and is low in carbohydrates. The local care resolves itself into management of the bowels and the dressing Confinement of the bowels for four to seven days is desirable, as gross soiling of the open wound is thereby avoided until granulations appear. Thereafter a daily enema is given, the wound is protected by vaseline-gauze, and the bowels are opened, this being followed by a warm bath when the patient is well enough, after which the new dressing is applied.

Applications to the Abscess.

After the operation, a large compress of acriflavine-paraffin emulsion is laid on the wound; this aims at arresting the action of the bacteria on the freshly incised surface, and is comfortable by being non-adherent. When granulations appear, if the abscess-cavity is still purulent, compresses of eusol or of Dakin's solution are used four-hourly. When the entire wound is clean, hypertonic compresses of sodium sulphate are used, and the process of granulation is stimulated by the addition of 1 in 1000 brilliant green.

When the granulations reach the surface, epithelialisation is encouraged by the use of lotio rubra, or of eusol and paraffin.

Thiersch or Pinch skin grafts may be applied. Healing around the anal margin

is chiefly encouraged. If the peripheral wound closes too quickly, the granulations are burned back by silver nitrate or copper sulphate.

Patients are not allowed up until healing is complete, which usually takes three to four weeks. If pain is marked, a rubber hot-water bottle over the compress is helpful.

Graduated exposure to ultra-violet or infra-red rays stimulates healing.

CHAPTER VII

Pilonidal Sinus

The skin of the middle line between the anus and the sacro-coccygeal junction is a line of fusion during development; consequently fragments of skin may be enclosed and retained in the subcutaneous tissues. These fragments of epithelium give rise to certain symptoms, usually between the ages of sixteen and thirty-five; they are:

(1) Boils or abscesses.
(2) Persistent sinus with eczema and pruritus.
(3) Tumour formation.

(1) *Boil or abscess formation.* The infection may arise spontaneously without the patient being aware of a previous sinus, or it may develop in an already declared track. Occasionally the infection develops in a cyst. The inflammation is frequently recurrent, this being the factor which attracts attention. Whilst the abscess is draining, a probe can easily be passed down to bone, but after healing no external opening may be visible for a period.

(2) *Sinus.* One or several sinuses may be present in the region of the sacro-coccygeal junction. Hair often protrudes from them and pressure expresses sebaceous material. A small probe is readily admitted and passes down to bone in a direction away from the rectum and anus, for the two are in no way connected. The sinuses are not more than one inch removed from the mid-line. Their complete extent can be defined by the injection of lipiodol followed by a skiagram of the part. Occasionally they pass through and beyond the sacro-coccygeal joint into the pelvis. It is the continuous discharge, often odoriferous and profuse, which attracts attention. They may be the overlooked cause of persistent pruritus and eczema.

(3) *Tumour.* A tumour in the sacro-coccygeal area is a true sequestration dermoid. It lies somewhat to one side of the middle line; no external orifice is seen in some cases, but in others it occasionally discharges and then seals up. For long periods it may cause no symptoms, but inflammation usually leads the patient to seek medical aid.

Treatment

(1) The care of the acute condition until it is quiescent.

(2) The excision *en masse* of the affected area and the obliteration of the resulting cavity.

The eczema, pruritus and discharge respond readily to a regular toilet of soap and water followed by an application of astringent lotions, e.g. 1 in 1500 perchloride of mercury. Patients with boils and abscesses are put to bed, hypertonic compresses are applied, and incision may be required.

Anæsthetic. A low spinal anæsthetic is given.

Position. The patient is placed face downwards on the operating table, which is tilted into a slight Trendelenburg position. The foot-piece of the table is then completely lowered so that the patient is now well flexed and the part freely exposed. The left lateral position is an alternative, but in my experience this is not so convenient.

Preparation. The area is painted with pure dettol, iodine 2·5 per cent, picric acid 1 per cent, or Bonney's crystal violet. The application begins at the lumbar spine and passes systematically downwards, finally touching and finishing at the anus. A swab soaked in an antiseptic is tucked in over the anus and retained by a stitch.

The difficulty of the operation is to obtain primary union in the deep narrow wound remaining after the excision. Three points militate against healing: (*a*) The presence of infection from the anus; (*b*) the fixity of the subcutaneous tissues and the deep fascia; and (*c*) the slow healing of the coarse skin and fat.

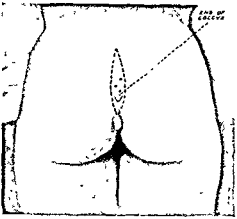


Fig 2949.—EXCISION OF PILONIDAL SINUSES Note especially the lines of incision, and exclusion of the anus by a pad.

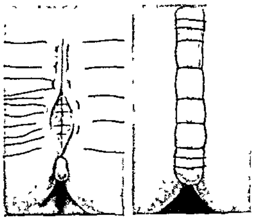


Fig 2950.—EXCISION OF PILONIDAL SINUSES. Note the method of suturing and of anchoring the dressing.

It is taught that the adipose tissue in this area is poorly vascularised, but at operation bleeding will be found to be copious and troublesome.

Operation. When a sinus is present, a probe is passed down it; the direction is inwards and upwards towards the middle line. The skin is excised in an ellipse well wide of the orifice or orifices, beginning considerably above it and finishing below the tip of the coccyx (fig. 2949). The ellipse must be long so as to render it comparatively narrow in order to assist the closure. The incision is deepened vertically down to the deep fascia and to the sacrum and coccyx on each side. The free bleeding is controlled by a firm pack which is advanced over the wound edges by the left hand as the wound is deepened; it also acts as an efficient retractor. The ellipse of skin is seized by two pairs of Lane tissue forceps, and held away from the surgeon by the assistant. The other side is similarly treated Rarely the sinus passes through the sacro-coccygeal joint, but it is unwise at this stage to continue the operation further. A probe dipped in pure carbolic acid is passed along the track as far as possible, with the object of destroying its epithelium. The bone and aponeurosis reached, the fatty tissue is dissected cleanly off it by the scalpel, leaving a cavity of about 1 to 2 inches deep.

The bleeding is controlled by a hot firm pack held in position for one minute,

and spurting vessels are picked up and tied with the finest plain catgut; it is important to leave a minimum of crushed tissue and of foreign matter in the wound, but hæmostasis must be perfect or otherwise a hæmatoma will collect and separate the wound surfaces.

The obliteration of the cavity after a radically performed operation is difficult. *The sides are mobilised by undermining the subcutaneous tissues from the deep fascia by blunt dissection with a periosteal elevator.*

Raising the legs slackens the wound tissues. Two layers of sutures are required. The skin is re-sterilised, and thick silkworm-gut is inserted starting 1 inch from the skin edge and passing to the full depth of the wound. If the patient is stout, then a figure-of-eight type of suture is used, the ends being held by hæmostats. The space between these through-and-through sutures is obliterated by stitches of fine plain catgut, which are circular or figure-of-eight according to the size of the space. They are all inserted first and tied afterwards, beginning at either end and working towards the widest part of the gap, whilst the assistant presses the edges together. The skin is closed by fine silkworm-gut blanket sutures accurately inserted, tensioned and tied carefully to evert the skin edges, but not so as to cause necrosis from excessive tension (see fig. 2950).

A firm roll of tulle gras or of gauze, soaked in acriflavine emulsion or vaseline, is placed on the wound and the large silkworm-gut stitches are tied over it; their tightness is judged nicely. This moist or greasy pack sets as a semi-stiff splint to the part.

The After-Treatment of Pilonidal Sinus

The after-treatment of pilonidal sinus is important. The essential is to maintain the fatty surfaces of the wound at rest during healing (about ten to twelve days), to avoid the movements associated with defæcation or soiling by fæces, and to eliminate pressure on the part.

The diet consists of glucose-sweetened fruit drinks for twelve days; these are well tolerated when the reason for their use is explained. The patient lies on the face without a pillow, and is turned on to the sides for relief. With the fruit drink diet no action of the bowels is required until the eleventh day, when an olive oil and turpentine enema is given, the bowels are opened, and only then is the first dressing made. All the sutures are removed, and a piece of sterile gauze impregnated with vaseline is applied. The buttocks are firmly strapped together with elastoplast.

Normal diet is gradually resumed, and the bowels are opened on alternate days. Patients get up on the fourteenth day, and live a quiet life for a further fortnight as there is still the risk of tearing apart the wound surfaces.

The writer has used this after-treatment in sixteen cases; all have healed by first intention.

CHAPTER VIII

A. Lumbar Puncture

Lumbar puncture is the operation of tapping the spinal theca in the lumbar area by the insertion of a needle below the termination of the spinal cord.

Indications for Lumbar Puncture

(1) *Diagnostic.* For the investigation of traumatic, inflammatory, and neoplastic lesions of the central nervous system.

(2) *Therapeutic.* Various drugs and sera are injected into the spinal theca in the treatment of certain diseases; e.g. anti-tetanic serum and carbolic acid in the treatment of tetanus; salvarsanised serum in the treatment of G.P.I. and tabes; and alcohol for the persistent pain of malignant disease and some nerve lesions.

(3) *Spinal anæsthesia.* Drugs frequently used are novocaine, percaine, stovaine, planocain, durocain, etc. (For further details see Vol. I, page 35.)

Instruments

The instruments required include:

(1) *Needles.* Lumbar puncture needles and a spinal manometer. The bore of the needle should not be larger than 18, the ideal being 20, whilst 22 is suitable for children.

(2) *Syringes.* Three are required: (*a*) Hypodermic syringe with needle and ½ per cent novocaine for skin anæsthetic; (*b*) syringe for the withdrawal of cerebro-spinal fluid; and (*c*) suitable syringe containing the medium to be injected.

(3) *Sterile test-tubes* to receive the cerebro-spinal fluid.

The instruments are sterilised by boiling in doubly distilled water.

Position of the Patient

Lumbar puncture is performed with the patient in one of two positions: either sitting up with the spine flexed forward on to the knees (see fig. 2951), or in the lateral position with the trunk well flexed (see figs. 2952 and 2953). The needle is inserted exactly in the middle line; *a slight deviation from this will result in an unsuccessful or unsatisfactory puncture* owing to the triangular shape of the thecal canal (see fig. 2954).

Procedure

The entire spine is exposed, and a rectangular area is sterilised as for a surgical operation between the iliac crests, upwards to the dorsal area and downwards to the tip of the sacrum. I find it useful to indicate the 7th dorsal spine by touching it with iodine, as it assists in the orientation of the line of the spinal canal and consequently in the accuracy of the puncture. The puncture may be performed through the spaces lumbar 2–3, 3–4, or 4–5; the last is indicated by placing the

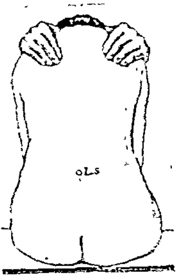


Fig 2351.—LUMBAR PUNCTURE. CORRECT SITTING POSITION.

Note the position of the assistant's hands arching the patient's spine.

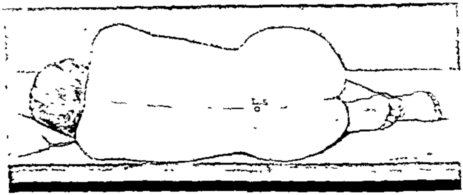


Fig 2352.—CORRECT POSITION FOR A LUMBAR PUNCTURE IN THE LATERAL POSITION.

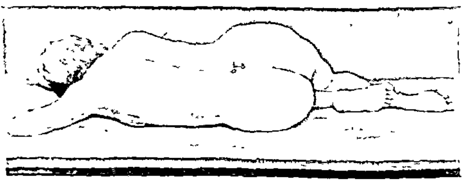


Fig 2353.—LUMBAR PUNCTURE IN LATERAL POSITION—INCORRECT POSITION. Note the twisted, oblique spine.

stretched edge of a sterile towel across the lumbar area, and feeling through it for the iliac crests. When these are located exactly, the edge intersects the middle line in the space between the 4th and 5th spinal processes of the lumbar vertebræ.

The needle is gripped in one of two ways (figs. 2955 and 2956), both of which are efficient and their use is merely a matter of practice. After the needles have been sterilised they should be thoroughly *rinsed in sterile distilled water*. A freshly sharpened needle is always necessary, as points are easily damaged and broken off by contact with bone, thereby rendering a clean puncture difficult or unlikely. A blunt needle pushes the dura forwards rather than penetrating it.

In the unanæsthetised patient, a small wheal is raised on the skin by the injection of 1 cc. of $\frac{1}{2}$ per cent novocaine. Freezing the site for puncture with ethyl chloride is a satisfactory alternative. The needle is inserted precisely in the middle line, exactly *at right angles to the plane of the inter-iliac crests*, and is pressed

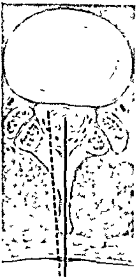


Fig 2951.—Lumbar puncture

Note how a slight deviation *results in a dry puncture.*

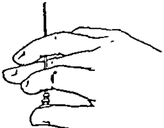


Fig 2955.—Lumbar puncture. Alternative method of holding the needle.

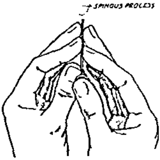


Fig. 2956.—Lumbar puncture. *Grip of the needle.*

forwards horizontally. Estimation of the direction requires practice, but it is approximately horizontal. The needle is steadily inserted for about 2 inches and if bone is touched it is withdrawn for 1 inch and then inserted with the tip lowered or raised. Contact with the inter-spinous ligaments is indicated by increased *resistance* for about $\frac{1}{8}$-inch, followed by a *sensation of freedom to the needle point.* Following this, a crisp impression as of the needle penetrating a diaphragm is detected by the practised hand, and the spinal canal is entered. The *trocar* is withdrawn and cerebro-spinal fluid usually appears, if not, the needle is sharply rotated with the object of clearing the point of theca or of the lumbar nerves. If fluid is still absent, the needle is slowly withdrawn or advanced. Blood may exude as the result of pricking a vein outside the theca; of course, the cerebro-spinal fluid may be blood-stained in cases of head injury. When blood appears in a therapeutic puncture, insertion into a higher or lower space is indicated. *If the hæmorrhage continues*, it is advisable not to inject a spinal anæsthetic. Failure to draw cerebro-spinal fluid is usually due to non-entry of the theca, or to

insertion of the needle in the wrong axis. Blocking by blood clot may occur, and must be cleared by the stilette. The point may be covered by theca, but a quick rotation will pierce it. The orifice may be entangled in one of the lumbar nerves in the spinal canal, and considerable manipulation and patience are sometimes required before fluid can be easily drawn with a syringe from the theca. The incorrect position of the patient often explains an unsuccessful puncture. He must be exactly upright, or, if lying on his side, the plane of the iliac crests must be exactly vertical, the spine being well flexed in both attitudes. In some adults the spine is rigid, they are unable to flex, and the space between the vertebræ is so narrow that lumbar puncture is difficult and occasionally impossible. Forcible flexion of the patient is usually followed by entry of the needle into the theca. In a small proportion of subjects cerebro-spinal fluid does not appear until it is aspirated by the syringe.

Dangers of Lumbar Puncture

(1) *Meningitis.* Fatal cases of sepsis introduced into the subarachnoid space have occurred; therefore, sterilisation of all instruments by boiling is necessary; chemical sterilisation by spirit, lysol, etc., is not dependable, and if these agents are not effectively removed before the introduction of a spinal anæsthetic severe headache, often due to a mild chemical aseptic meningitis, may follow. The stilette is withdrawn from the needle during the heating.

Septic meningitis is, fortunately, a very rare complication. Paraplegia rapidly develops and death follows in a week.

(2) *Injury to a nerve root* follows perforation by the needle, but is not common. It is due to a considerable deviation of the needle from the middle line. An alternative explanation is that of pricking the peri-thecal veins and causing a hæmatoma which presses on the nerve. Wasting of the affected muscles follows, requiring splinting and months of treatment before recovery ensues.

(3) *Headache* follows some lumbar punctures, whether performed for diagnostic, for therapeutic, or for anæsthetic purposes. Several theories are current to explain this:

(*a*) A continued leak of cerebro-spinal fluid into the peri-thecal tissues; this may be so after the use of the old-fashioned thick needle but with the present-day fine needles, headaches occur much less frequently.

(*b*) Bleeding into the spinal canal or peri-thecal tissues. Headaches may occur when no sign of hæmorrhage from the needle is seen.

(*c*) A small area of traumatic aseptic meningitis. The headache usually comes on within two to three days after the operation and may last for many days or even for several weeks.

In my experience, headaches have lessened since sterilisation has been performed by boiling in doubly distilled water, and all chemicals, e.g. spirit or carbolic acid, have been eliminated from all the instruments used in the operation.

(*d*) The skill of the operator. The incidence of headaches falls as the operator's skill develops.

By keeping the patient flat without a pillow or by raising the foot of the bed for twenty-four hours the incidence of headache is diminished. The headache usually responds to four-hourly doses of aspirin, phenacetin and caffeine, but failing this, and the patient's general condition permitting, an injection of ½ cc. of pituitrin or of ephedrine ½ gr. generally gives some relief. In obstinate cases an intravenous

injection of 30 cc. of a 30 per cent saline, perhaps repeated, rapidly terminates it. This remedy is not advisable in lesions of the central nervous system.

(4) *Incontinence of urine* is an unusual complication, which is temporary as a rule, and resolves in several days, although it sometimes lasts for several weeks. Rarely is the condition permanent.

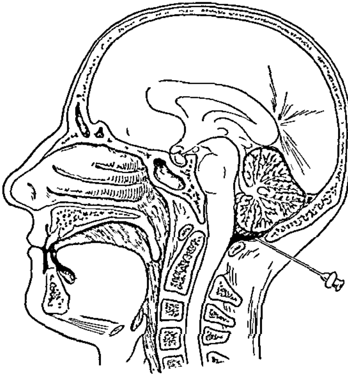
B. Cisternal Puncture

by

Harold Dodd and Harvey Jackson

Cisternal puncture is the insertion of a needle into the cisterna magna at the base of the brain, and is used for diagnostic and therapeutic purposes (fig. 2957)

Fig 2957.—Cisternal puncture.



Indications

(1) *Diagnostic.*

(*a*) For the withdrawal of cerebro-spinal fluid.

(i) Where lumbar puncture fails.

(ii) When information as to the relative concentrations of the constituents of the fluid in the cistern and lumbar sac is desired.

(*b*) For the determination of the exact level of a spinal tumour by the cisternal injection of heavy lipiodol.

(*c*) For the injection of air in the investigation of "encephalography."

(2) *Therapeutic.*

(*a*) For the administration of sera, e.g. anti-tetanic serum.

(*b*) To wash out the theca when a simultaneous lumbar puncture is performed.

Position of the patient. A suitable position for the patient is sitting up in bed with the hands on a "heart table," and the forehead resting on the hands. This suitably flexes the neck, and draws the medulla forward so that it is less likely to be touched by the needle.

The occipital region is shaved, washed, and painted with iodine.

Procedure A wide-bore needle (1 mm.) is used; the length should be 7 cms. with a groove marking 6 cms. A superficial injection of novocaine is given midway between the tips of the mastoid processes, or just above the highest palpable cervical spinous process. The cisternal needle is inserted in the middle line at this site and directed towards the nasion. The penetration is continued until the occipital bone is encountered, or, if bone is not felt, a depth of 6 cms. is attained. Insertion beyond 6 cms. is not made without caution. On contact with the occipital bone the needle is partly withdrawn and reinserted with the point slightly depressed, so that it passes under the posterior edge of the foramen magnum. As the needle progresses, resistance by the occipito-atlantal membrane and the spinal dura mater will be recognised. These structures pierced, a syringe is applied, and aspiration is made to withdraw the cerebro-spinal fluid; this is necessary for, in the absence of increased intra-cranial tension, and with the patient in the upright position, the intra-cranial tension in the cisterna magna is below atmospheric pressure and cerebro-spinal fluid will not escape unassisted. On the average the cistern is at a depth of 3–4 cms.

PART XXXIX

SOME NEUROLOGICAL AND PSYCHIATRIC ASPECTS OF SURGERY

by
T. Rowland Hill

SOME NEUROLOGICAL AND PSYCHIATRIC ASPECTS OF SURGERY

In this article will be considered some of the more important pathological states of the nervous system and mental function that may influence the work of the surgeon. Those conditions which have already been fully described in previous sections of this work will be omitted.

Disease-processes of the nervous system will be discussed under the headings: Brain, Cranial Nerves, Spinal Cord and Peripheral Nerves, and Disorders of Muscular Power and Tonus, whilst, in addition, separate consideration will be given to the subjects of Coma and Delirium, Anxiety and Hysteria.

CHAPTER I

Brain

RISE OF INTRA-CRANIAL TENSION

The signs and symptoms of this condition may or may not be due to a pathological process from which surgical treatment can give relief. Whatever its cause, however, it is of importance to the surgeon, because his aid may be needed in diagnosis as well as in treatment. Rise of intra-cranial tension may be acute or chronic. Causes of acute rise in tension are: (1) Head injury (contusion or compression); (2) Intra-cranial hæmorrhage (cerebral and spontaneous subarachnoid); (3) Acute meningitis; (4) Intra-cranial abscess; (5) Intra-cranial venous sinus thrombosis; and (6) Acute hydrocephalus.

Sub-acute or chronic rise in tension may occur in: (*a*) Head injury; (*b*) Hydrocephalus; (*c*) Abscess; (*d*) Tumour; and (*e*) Granuloma.

The *general signs of raised intra-cranial tension* are familiar and have been described in Volume II, page 1760. The more acute the rise of pressure the more marked are the symptoms. When the rise takes place slowly, and especially when it is accompanied, as it often is, by a mild degree of mental dulling, headache and vomiting may be slight or absent even though the rise may be considerable as shown by several dioptres of papillœdema. In such cases it is not unusual for the patient first to go to his doctor for failing eyesight due to the beginning of optic atrophy secondary to prolonged swelling of the disc.

(1) *Head Injury.*

Full consideration is given to this subject in Volume II, page 1747.

(2) *Intra-cranial Hæmorrhage.*

The commonest form is intra-cranial hæmorrhage in the neighbourhood of the internal capsule from spontaneous rupture of one of the branches of the

middle cerebral artery. It occurs usually during or after middle age and is secondary to atheromatous degeneration of the arterial wall. It is generally associated with widespread arteriosclerosis and with hyperpiesis. Clinically the onset is very sudden and not necessarily associated with muscular effort or any other factor raising the blood-pressure. Loss of consciousness is nearly always seen and may be instantaneous or be preceded by a period of a few moments during which severe headache is felt. The signs of cerebral compression such as deep stertorous breathing and slow full pulse will be seen as in intra-cranial hæmorrhage following head injury. If death occurs it may take place as soon as three or four hours after the onset or it may be delayed for several days.

The presence of hemiplegia may be detected by the flaccidity of the affected limbs and by their immobility if the patient is not completely unconscious. The

Fig. 2038.—INTRA-VENTRICULAR HÆMORRHAGE.

head and eyes may be turned towards the side of the lesion. The cerebro-spinal fluid will be under increased pressure or may—if the hæmorrhage has reached the lateral ventricle—contain fresh blood. Spontaneous cerebral hæmorrhage may need to be differentiated from intra-cranial bleeding following upon a head injury, for in the former condition the patient may have fallen unconscious and struck his head. His age, signs of general atheroma such as thickened and tortuous radial vessels, and the minor character of the trauma to the head will assist in diagnosis. Spontaneous cerebral hæmorrhage has been treated surgically by performing a craniotomy on the side of the lesion and removing all blood clot.

Probably the best treatment is immediate venesection with removal of one pint of blood and the injection of hypertonic saline (100 cc. of 50 per cent glucose-saline intravenously at the rate of not more than 3 cc. per minute). Lumbar puncture may be performed if unconsciousness deepens, but there is always the risk of sudden death from pressure-cone formation in the foramen magnum.

Spontaneous Subarachnoid Hæmorrhage.

Effusion of blood into the subarachnoid space may occur in a number of conditions. For example, a hæmorrhage in the region of the internal capsule can reach this space by spreading externally through the cerebral substance. The bleeding may be secondary to a head injury. Such causes should, however, be readily detectable and the primary condition overshadows in importance the

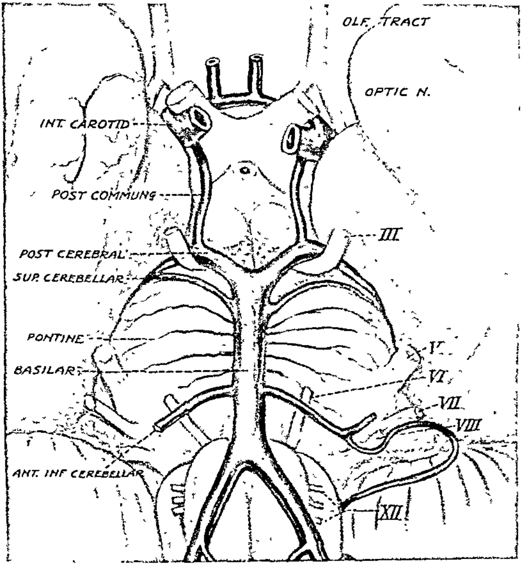


Fig 2959.—Diagram of the circle of Willis

subarachnoid character of the hæmorrhage. Nevertheless, there is one disease-process, *congenital cerebral aneurysm*, which is of surgical importance and which is nearly always associated sooner or later with spontaneous bleeding into the subarachnoid space. Congenital aneurysms, presumably the result of developmental failure in the proper formation of the arterial walls, may occur in any of the superficially placed arteries of the brain, but they are most frequently seen in the neighbourhood of the circle of Willis at the base of the brain (the common site being at the junction of the anterior cerebral with the anterior communicating

artery) or on the middle cerebral artery. They may be single or multiple. The existence of such aneurysms prior to their rupture is exceedingly difficult to detect. Often, no symptoms result from their presence. If any signs are produced they will be those of local pressure, such as interference with adjacent cranial nerves. The optic nerve may be compressed with unilateral failure of vision—possibly intermittent in character—or the 3rd, 4th or 6th nerves may be affected with resultant ocular palsies. Involvement of the first division of the trigeminal nerve produces neuralgic pain in the supra-orbital region and, sometimes, loss of the corneal reflex. The aneurysms are rarely large enough to give rise to symptoms of increased intra-cranial tension, though, if they are close to the pons or mid-brain, pressure on the pyramidal tracts or cranial nerve nuclei, such as those of the 3rd, 5th, 6th and 7th, may occur. I have seen a rapidly fatal internal hydrocephalus result from an aneurysm of the basilar artery. Congenital aneurysms nearly

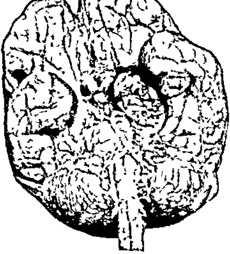


Fig 2960.—Large unruptured congenital aneurysm of the left side of the circle of Willis. Slight leakage has taken place at the tip of the temporal lobe.

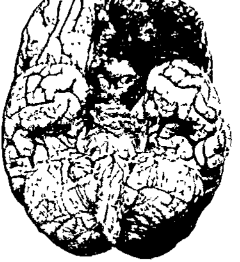


Fig 2961.—Ruptured congenital aneurysm of the circle of Willis, showing effusion of blood over inferior surface of the left frontal lobe (diffuse subarachnoid hæmorrhage)

always rupture sooner or later, but generally after the age of forty when some degree of arterial degeneration has added to the weakness of their walls or when a rising blood-pressure has increased the strain upon them. Rupture may be spontaneous or be precipitated by sudden rise of blood-pressure as, e.g., during exertion. The effect of rupture may be to produce the picture of severe subarachnoid hæmorrhage and be fatal. Unconsciousness may result immediately, or a condition appear resembling cerebral irritation, the patient lying curled up, semi-conscious and resistant to interference. Meningitic signs such as a positive Kernig and neck rigidity are likely to be seen. On lumbar puncture free blood will be found in the cerebro-spinal fluid. Generally, the first rupture of an aneurysm is not fatal. Recovery from the condition just described takes place or else the first rupture, or perhaps the first two or three ruptures, of the aneurysm are less severe and produce slighter effects. The onset of hæmorrhage may be signalised by severe headache and vomiting, associated with, perhaps, transient unconsciousness, to

be followed by paralysis of cranial nerves or signs of pressure on nerve tracts in the neighbourhood of the aneurysm. If the latter is anteriorly placed in the region of the anterior communicating artery, affection of the optic nerve or of the chiasma is common. The motor nerves to the ocular muscles, the 3rd, 4th and 6th, may be involved in the outer wall of the cavernous sinus, or homonymous hemianopia may result from damage to the optic tract or, if the aneurysm be on the posterior cerebral artery, from damage to the optic radiation. The hæmorrhages tend to recur at intervals of months or years and, if untreated, sooner or later prove fatal. The terminal hæmorrhage may produce its effects gradually, as in the case described by Jefferson of a woman who, feeling ill in the street, walked home, climbed upstairs and lay on her bed, to be found dead some time later. Recovery from the initial

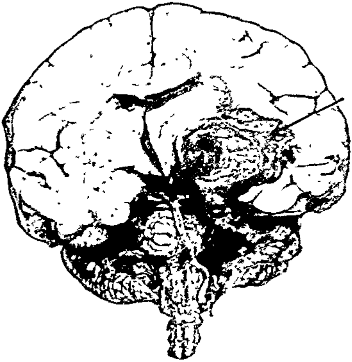


Fig. 2962.—RUPTURED CONGENITAL ANEURYSM OF THE CIRCLE OF WILLIS.
(From the West End Hospital for Diseases of the Nervous System, by courtesy of Dr. W. E. Carnegie Dickson.)

hæmorrhages is often incomplete, as in a case of mine, a young man, whose first hæmorrhage produced homonymous hemianopia which has never disappeared.

The diagnosis after rupture is a fairly straightforward matter. Intra-cerebral hæmorrhage commonly produces hemiplegia and is associated with signs of atheroma and hyperpiesis. The history of previous ruptures, if obtainable, is distinctive, and confirmation is obtained by the finding of free blood in the cerebrospinal fluid. The precise situation of an aneurysm can be determined, and conclusive evidence of its presence can be obtained by means of an angeiogram if the aneurysm, before rupture, is only suspected. The angeiogram consists of an X-ray photograph of the cerebral blood-vessels after they have been rendered opaque by the intra-arterial injection of thorotrast. The internal carotid artery is exposed in the neck and 10 cc. of thorotrast are injected into it. Exposures are made immediately after the injection, and at intervals of two seconds and four seconds later. The first negative shows the arteries of the brain, the second the capillaries, and the third the veins and venous sinuses. Aneurysms, especially those in the anterior part of the circle of Willis, are readily detected.

Treatment of intra-cranial aneurysm consists of ligature of the corresponding internal carotid artery whenever this is feasible, the risk of hemiplegia being borne in mind. If the aneurysm is on an accessible branch of, say, the middle cerebral

Fig 2963.—Normal arteriogram.

artery, this may be susceptible to ligature. During the acute phase of a subarachnoid hæmorrhage, measures to lower intra-cranial tension must be taken. Repeated spinal drainage should be performed (slowly, with a small needle, because

Fig 2964.—Normal phlebogram.

of the risk of pressure-cone formation) and intravenous hypertonic solutions may be injected. The danger of exciting fresh hæmorrhage by allowing cerebrospinal fluid to escape is probably much less than has often been alleged.

(3) *Acute Meningitis.*

The various forms of this condition may be classified as follows: (*a*) Tuber-

culous meningitis; (*b*) Meningococcal meningitis; (*c*) Meningitis from other pyogenic organisms; and (*d*) Acute serous meningitis.

Tuberculous Meningitis. This is to be regarded as a manifestation of an acute general tuberculous infection—a tuberculous septicæmia, though some observers

Fig 2965.—Angioma of the left parietal lobe and two aneurysms of the internal carotid artery.

have regarded occasional cases as being confined to the nervous system. It is commonest in young children though it may occur at any age. A primary focus somewhere in the body is probably always present and is most frequently found in infected lymph glands, though local tuberculous lesions anywhere may lead to

Fig. 2966.—Aneurysm in a branch of the Sylvian artery.

general dissemination of the bacillus. Such dissemination may be secondary to surgical interference with, say, a diseased bone or joint or an intra-cranial tuberculoma. Quite often in young children evidence can be found of exposure to mass-infection, as in the case of a child who slept in the same bed as his father who suffered from open pulmonary tuberculosis. In adults, meningitis may close the scene after years of chronic tuberculosis. This form of meningitis is character-

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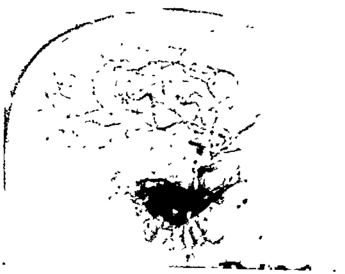

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ised by its insidious onset with a prodromal period of vague malaise lasting several weeks. Loss of weight and appetite and psychological symptoms such as irritability, or even delirium, are characteristic. The meningitic signs as they gradually appear have certain distinctive features. Headache will occur and vomit-

Fig. 2967.—Aneurysm of internal carotid artery.

ing may be present, but head retraction is slight or absent. On the other hand, palsies of cranial nerves, especially of the 3rd, 4th and 6th, with the production of strabismus, are common. Clouding of consciousness, often with brief remissions, steadily advances, cachexia develops, and death inevitably results a few weeks—

Fig. 2968.—Aneurysm of the origin of the anterior cerebral artery.

(*Arteriograms, by courtesy of Dr. Lima of Lisbon.*)

usually about a month—after the onset of meningitic signs. The cerebro-spinal fluid shows typical changes. On withdrawal, though under pressure, it is clear, but on standing a delicate web-like clot of protein forms. The chloride content is markedly reduced (to about 600 mgm. per cent or lower), as is also the glucose content. There is a moderate pleocytosis of about 100 cells per mm., predomin-

antly lymphocytic. The total protein will be raised (0·1 per cent). Treatment is symptomatic.

Meningococcal Meningitis. The onset is acute, meningitic signs usually appearing within twenty-four hours. Headache is severe and vomiting generally present. Head retraction and Kernig's sign are marked, and cranial nerve palsies, especially of the 3rd, 4th and 6th nerves, are common. The temperature is high but the pulse is often slower than would be expected. The disease may occur in epidemics, usually in the winter and spring, or sporadically at any time of the year. It is only mildly contagious and may be nursed in general hospital wards without much danger. Epidemics are associated with overcrowding; they occurred, for example, during the war among soldiers in barracks. Spread takes place by carriers, the most serious of whom consist of healthy contacts who carry the organism in their naso-pharynx for several weeks after exposure to an infected person but who do not, except in rare cases, develop the disease themselves. Convalescent cases may sometimes carry the organism in their naso-pharynx for months after recovery. Spread takes place via the secretions of the nose and throat. Examination of the cerebro-spinal fluid shows turbidity or purulency practically from the start of the illness. The fluid is under high pressure (300 mm.) and the protein content is much raised (400 mgm. per cent); later clotting may occur on standing. The glucose content is generally reduced, but the chloride only slightly. Heavy pleocytosis, predominantly polymorphonuclear, takes place, the cell-count being 1000–2000 per c mm. The causative organism, a Gram-negative diplococcus, can always be found in the fluid, chiefly within the leucocytes, but it may not be seen on direct smears and is sometimes grown with difficulty. The Lange gold curve is meningitic in type.

The disease is commonest in children and is rare after middle age.

The details of treatment by repeated spinal drainage and administration of serum need not be described. The mortality in untreated cases is from 50 to 100 per cent but under adequate treatment this should fall to not more than 3 per cent. Permanent sequelæ in recovered cases are common in such forms as ocular palsies, hemiplegia, mental defect, blindness, or, characteristically, bilateral deafness. There is a complication of meningococcal meningitis which is of surgical importance—hydrocephalus. This is produced by the presence of exudate over the roof of the fourth ventricle and in the cisterna magna and cisterna pontis. Its appearance is heralded during the course of an attack of meningococcal meningitis by an exacerbation of symptoms. Increased headache, drowsiness and bradycardia may develop, and lumbar puncture reveals in some cases a dry tap or sub-normal pressure. When hydrocephalus develops, the lateral ventricle should be tapped by a brain needle inserted through a burr hole in the postero-parietal region. If organisms are present in the ventricular fluid, serum should be injected in rather less quantity than the amount of fluid removed. If tapping and intra-ventricular injection of serum are repeated as often as necessary, the hydrocephalus may disappear and recovery take place. Prolonged hydrocephalus may follow meningococcal meningitis, particularly in the chronic form of the infection in infants under two years of age, which is known as posterior basic meningitis. The condition is of interest to the surgeon in view of the experiments in permanent operative relief that have been made.

Meningitis from other Pyogenic Organisms.

This is produced by infection of the leptomeninges with pyogenic organisms, most commonly the pneumococcus, streptococcus or staphylococcus. The onset is acute with pyrexia, e.g. 102° F., but with a pulse slower than would be expected. Headache, vomiting, delirium, and the various meningitic signs seen in meningococcal meningitis appear. The condition must be distinguished not only from tuberculous and meningococcal meningitis but also from the pseudo-meningitis or meningism that may occur, especially in children, during the course of general infections such as typhoid fever, pneumonia and acute specific fevers, or

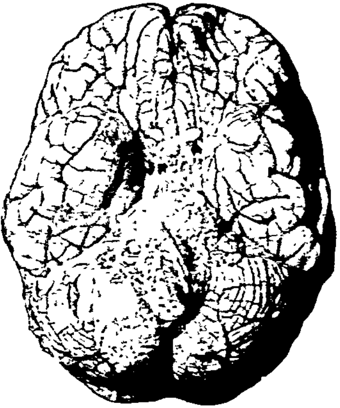

Fig. 2909.—Pyogenic meningitis secondary to otitic inflammation, showing exudate in cisterna pontis, which impedes flow of cerebro-spinal fluid over the convexity of the cerebral cortex and facilitates the development of hydrocephalus.

may be associated with otitis media or mastoiditis. Meningitic signs—signs of meningeal irritation—may also accompany acute encephalitis, acute disseminated encephalo-myelitis, cerebral abscess, and acute anterior poliomyelitis, or may be the sign of a local as distinct from a diffuse leptomeningitis secondary to spread of infection from the middle ear, mastoid, or frontal sinus. Acute serous meningitis must also be distinguished. In any case of doubt the diagnosis is clinched by examination of the cerebro-spinal fluid which will be under high pressure (300 mm.), be turbid or purulent, and show a heavy polymorphonuclear pleocytosis (1000–2000 cells per c.mm.) and raised protein content. Glucose will be much reduced in quantity or absent ; there will be a meningitic gold curve and the causative organism will be discovered in direct smears and on culture. Acute pyogenic meningitis is most commonly secondary to acute or chronic otitis media, mastoiditis, or labyrinthitis. Direct extension takes place through the tip of the tegmen

tympani, the labyrinth, the petrous portion of the temporal bone, or along the route of the 7th or 8th nerves. Less often, extension of infection takes place from the frontal, ethmoid or sphenoidal sinuses, and may follow curettage. Diffuse meningitis may result from spread of a previously local meningitis secondary to otitic infection, from a cerebral abscess, from sinus thrombosis or from entry of infection after a fracture of the skull that passes through the middle ear or one of the air sinuses. It may also appear secondary to superficial infections of the face and scalp such as erysipelas and carbuncle, and may complicate acute general infections such as influenza, typhoid fever, lobar pneumonia and typhus. From the surgical point of view, in investigating a suspicious case the absence of signs of diffuse meningitis in the cerebro-spinal fluid should not lead the observer too lightly to make a diagnosis of meningism. Meningism may be the earliest, or prodromal, sign of an oncoming true diffuse meningitis. If the cerebro-fluid signs, therefore, are negative, close search should be made for a local focus of infection, especially in the middle ear or mastoid. If this is found and is rapidly dealt with surgically, the disaster of diffuse meningitis may be averted.

In the earliest stage of meningitis the cerebro-spinal fluid, as stated, may show negative findings ; in the next stage, changes in the fluid may be found and even organisms be discovered but without a true diffuse meningitis being present. Therefore, the finding of pyogenic organisms in a case with early meningitic symptoms does not mean that diffuse meningitis cannot be averted by prompt surgical eradication of the primary focus. The slightest possibility of the infection not yet being diffuse should lead to instant operation being carried out. After diffuse infection of the meninges has occurred the prognosis is of the gravest. Practically all cases of pneumococcal meningitis are fatal. Repeated spinal drainage should be carried out, ventricular drainage can be performed if hydrocephalus develops, the ventricular system can be washed through with Ringer's solution with a needle in the lateral ventricle and another in the cisterna magna, and permanent drainage of the latter (Dandy, Haynes) may be performed by opening the dura and stitching in the funnel-end of a rubber catheter. Permanent drainage in a few cases has given hopeful results. Pneumococcal or streptococcal serum may be injected intra-thecally in appropriate cases, and urotropine 30 grs. t.d.s., with enough potassium citrate to make the urine alkaline, should be given. At present few cases recover but there appears scope for the extension of surgical treatment.

Acute Serous Meningitis. This is sometimes known as acute aseptic meningitis. It closely resembles acute pyogenic meningitis in its onset and symptomatology. The cerebro-spinal fluid findings may even show a high pleocytosis—leucocytic, but perhaps becoming lymphocytic later. The condition is, however, characterised by the absence of organisms in the cerebro-spinal fluid and by its benign course. It tends to remit spontaneously after about one week of illness. Much relief is obtained from lumbar puncture, and this should be performed whenever indicated for relief of headache. The condition may run a sub-acute course and is sometimes fatal in infants. In diagnosis it must be carefully discriminated from the earliest stage of true diffuse pyogenic meningitis. Serous meningitis is often only diagnosed after recovery by reason of its benign outcome. It may be a complication of acute infections such as influenza and lobar pneumonia. It is said sometimes to run an intermittent or sub-acute course.

(4) *Intra-cranial Abscess* (see also Vol. II. page 1827, and also page 4678)

This condition produces rise of intra-cranial tension with general signs similar to those of cerebral tumour but with notable differences. Suppuration inside the skull arises most commonly by spread of infection from otitis media, mastoiditis or labyrinthitis and less frequently from frontal or sphenoidal sinusitis. It may also result from fracture of the skull, particularly when the fracture is compound and there is communication between the cranial cavity and the exterior. Metastatic abscesses may be associated with pyæmia or with suppuration elsewhere in the body. It is especially liable, of course, to follow empyema, lung abscess, and bronchiectasis. The onset of symptoms may be very acute, headache and

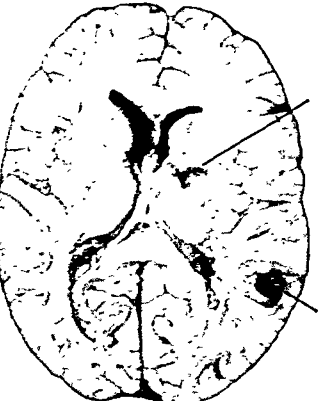

Fig. 2976.—Multiple abscesses secondary to pulmonary suppuration. The largest is seen in the right parietal region.

vomiting being marked and the former severe and constant rather than intermittent as in cerebral tumour. If the development of the abscess is less sudden, the headache may be very similar to that of tumour.

Intra-cranial suppuration may be: (*a*) Extra-dural; (*b*) Sub-dural; or (*c*) Intra-cerebral.

Intra-cerebral pus formation may be diffuse and spreading (acute suppurative encephalitis) or encapsuled. Extra-dural abscess, generally secondary to other infection, usually runs a sub-acute course with vague signs such as local pain and general malaise. It may be difficult to diagnose. Sub-dural abscess when of otitic origin is most often found in the temporo-sphenoidal lobe where its focal signs may be only slight. Homonymous hemianopia may be seen, and aphasic symptoms if the left cerebral hemisphere is affected. If in the cerebellum, focal signs of a cerebellar lesion may be very definite or, quite often, deceptively absent. When

present, homolateral cerebellar ataxia, nystagmus to the side of the lesion, and a tendency to deviate or fall to this side when walking will be seen. The development of otitic abscesses may be deferred until many weeks after an acute ear infection, with an intervening period of good health. Metastatic abscesses from blood-borne infection generally occur in the cerebral hemispheres and may be multiple. Development of symptoms is often gradual and, if the primary focus is overlooked, differentiation from cerebral tumour becomes difficult. On the other hand, the onset may be embolic and sudden. Examination of the cerebro-spinal fluid is sometimes of extreme diagnostic value. In intra-cranial abscess it may show increased pressure, a small polymorphonuclear exudate (100 cells per cmm.), a rise of total protein (0·1 per cent) and normal chlorides and sugar. It will be aseptic. These findings together with a polymorphonuclear leucocytosis in the blood may differentiate abscess and tumour when it is clinically difficult to do so. Common organisms in cerebral abscess are pneumococcus, streptococcus, staphylococcus aureus, and sometimes bacillus coli.

(5) *Intra-cranial Venous Sinus Thrombosis.*

This consists of three forms which are of clinical importance: (*a*) Lateral sinus thrombosis; (*b*) Cavernous sinus thrombosis; and (*c*) Superior longitudinal sinus thrombosis.

Sinus thrombosis is practically always secondary to an inflammatory process nearby. So-called primary thrombosis occurs, like broncho-pneumonia, in cachectic conditions at the extremes of life—infancy and old age. It is commonest in infancy and affects the superior longitudinal sinus. Signs of raised intra-cranial tension, such as headache, vomiting, and tenseness of the anterior fontanelle, are produced, the differential diagnosis from other causes of raised tension being difficult. Spastic paralysis of the legs due to vascular congestion of the upper Rolandic area may be seen together with congestion of the veins of the scalp.

Secondary sinus thrombosis occurs as a result of: (*a*) direct injury, e.g. fractures of the skull or penetrating wounds; and (*b*) spread of infection from neighbouring areas of inflammation.

The commonest site of thrombosis is in the lateral sinus as a result of spread of infection in mastoiditis, or less often from superficial inflammation of the scalp. The onset of thrombosis of this sinus may be difficult to diagnose. General headache and signs of raised intra-cranial tension will be superadded to the local signs in the ear. Thrombosis may extend into the jugular vein, which will be felt as a hard cord in the neck. The patient's general condition will deteriorate and he will show the signs of acute general infection, such as rigors and high swinging temperature. The full clinical picture of septicæmia or pyæmia may develop, and pulmonary embolism, characterised by sudden pain in the chest with the appearance of an area of consolidation with superjacent pleurisy, sometimes occurs. Œdema of the scalp in the neighbourhood of the mastoid process is likely to be seen, but local signs of damage to the brain are rare. Intra-cranial abscess or diffuse leptomeningitis may develop.

The cerebro-spinal fluid will be under raised pressure but will show few abnormalities on laboratory examination. A small rise in protein and a polymorphonuclear exudate are sometimes seen. Thrombosis of the cavernous sinus occurs as a result of spread of infection in frontal sinusitis, or in acute inflammation of the face such as boil or erysipelas. Œdema of the conjunctiva and eyelids is

produced with proptosis and congestion of the retinal veins. Spread to the opposite cavernous sinus often follows, and paralysis of the motor nerves to the eyeball in the outer wall of the sinus is common. Local pain around the orbit is experienced, and the signs of general infection may be seen.

Superior longitudinal sinus thrombosis is a rare sequel to frontal or ethmoidal sinusitis in adults.

Intra-cranial venous sinus thrombosis is a condition of the utmost gravity, and except in surgically treated cases of lateral sinus thrombosis is, with few exceptions, rapidly fatal.

(6) Hydrocephalus.

This may be defined as the presence within the cranial cavity of an excessive volume of cerebro-spinal fluid. When this is due to the replacement of a part of

Fig. 2971.—Ventriculography (lateral view). A case of internal hydrocephalus due to stenosis of the aqueduct of Sylvius. Note enlargement of the lateral ventricles is to be seen.

Fig. 2972.—Ventriculography (antero-posterior view). Pneumogram of the same case as depicted in *Fig.* 2971.

the cerebral substance, absent as a result of degeneration or abiotrophy, it is known as compensatory hydrocephalus, is associated with no rise in intra-cranial pressure, and is of no clinical significance.

Hydrocephalus producing rise in intra-cranial tension is either (*a*) congenital or (*b*) acquired, and, also, either (*a*) internal or (*b*) external. It may be the result of excessive secretion of cerebro-spinal fluid on the one hand, or of obstruction to the normal flow of cerebro-spinal fluid through the ventricular system or subarachnoid space on the other.

Congenital hydrocephalus is due to some obstructive lesion interrupting the flow of cerebro-spinal fluid and preventing its absorption by the arachnoid villi. Such lesions are atresia of the aqueduct of Sylvius or absence of the foramina of Majendie and Luschka or, as a result of birth injury, hæmorrhage into the cisterna magna and cisterna pontis blocking the subarachnoid space. Obstruction of the aqueduct or of the foramina in the roof of the 4th ventricle prevents the passage

of cerebro-spinal fluid from the ventricular system of the brain to the subarachnoid space, the hydrocephalus produced being known as internal. Blocking of the basal cisterns permits the fluid to leave the ventricular system of the brain via the foramina of Majendie and Luschka and thus allows free communication between the ventricles of the brain and the spinal subarachnoid space, but produces hydrocephalus by preventing the cerebro-spinal fluid from passing forwards and upwards over the convexity of the cerebral hemispheres to be absorbed through the arachnoid villi. This latter type of hydrocephalus is known as external or communicating. If the lateral ventricles are tapped and 1 cc. of phenolsulphon-

Fig 2973.—SKIAGRAM OF SKULL OF A PATIENT WITH CONGENITAL HYDROCEPHALUS WHO HAS LIVED UNTIL *MIDDLE LIFE*. NOTE SHAPE OF SKULL AND IMPERFECT BONE FORMATION, ESPECIALLY OVER THE REGION OF THE ANTERIOR FONTANELLE AND SUTURES

ephthalein is injected, the presence of this dye in the fluid on lumbar puncture ten minutes later shows the hydrocephalus to be external, whilst its absence proves the latter to be internal.

Internal hydrocephalus of the acquired type may occur at any age. It is produced by tumours in the lateral or 3rd ventricles which occlude the foramen of Monro or which, growing in the neighbourhood of the mid-brain as in the case of pinealomata, obstruct the aqueduct of Sylvius. A very common cause is a tumour or granuloma beneath the tentorium which acts as an obstructive lesion either by interference with venous drainage from the choroid plexuses or by occlusion of the 4th ventricle.

A cause of acquired internal hydrocephalus, which although not often seen should not be overlooked, is chronic inflammation of the ependyma of the ventricles. When the ependyma of the aqueduct of Sylvius is affected, blockage readily follows.

Acquired external hydrocephalus is produced most commonly by meningitis affecting the membranes in the region of the basal cisterns. It may occur, as previously described, in all forms of acute meningitis, where it adds gravely to the prognosis and where its early recognition and relief by tapping of the lateral ventricles are so important; in a case of meningococcal meningitis which survives the acute stage it may appear as a sub-acute or chronic condition. The

FIG. 2974.—MODERATE DEGREE OF INTERNAL HYDROCEPHALUS SECONDARY TO A MID LINE TUMOUR WHICH IS VISIBLE JUST POSTERIOR TO THE THIRD VENTRICLE.

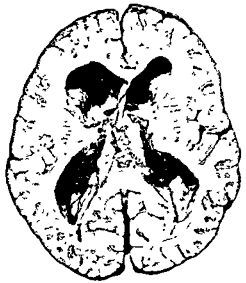

FIG. 2975.—MORE SEVERE DEGREE OF INTERNAL HYDROCEPHALUS SECONDARY TO A BASAL TUMOUR (ACOUSTIC NEURINOMA).

FIG 2976.—VERY SEVERE DEGREE OF INTERNAL HYDROCEPHALUS DUE TO OLIGODENDROGLIOMA VISIBLE IN THE FLOOR OF THE THIRD VENTRICLE.
(*By courtesy of Dr. W. E. Carnegie Dickson.*)

ill defined syndrome of chronic cystic arachnoiditis is to be placed as a cause in the same category.

Occasionally an external hydrocephalus develops "idiopathically" through excessive secretion of cerebro-spinal fluid. In some cases this follows otitis media or a blow on the head, and it is a common sequel to obstruction of venous drainage of the choroid plexuses in sinus thrombosis.

The clinical signs of hydrocephalus depend upon (*a*) the age of the patient, and (*b*) the degree of raised cerebro-spinal fluid pressure and the rate at which this

pressure rises. In congenital hydrocephalus and in childhood, separation of the sutures and great enlargement of the skull are commonly seen. If life is prolonged, the child usually shows mental retardation and may be an imbecile, though sometimes marked enlargement of the skull from juvenile hydrocephalus that has resolved is seen in adults whose intelligence is unimpaired. This compensatory enlargement of the skull appears to prevent the symptoms of rise of intra-cranial tension from being severe in children, for headache and vomiting are not often very prominent, but pressure upon the optic nerves with optic atrophy is common, and enlargement of the sella turcica, erosion of the clinoid processes and signs of dyspituitarism, such as obesity, may be observed as a result of downward pressure upon the floor of the 3rd ventricle. Weakness and spasticity of the limbs are frequent. Percussion of a skull with separated sutures may yield the "cracked pot" note. In adult life after the age of twenty, compensatory enlargement of the skull does not occur and the general symptoms of rise of intra-cranial tension are severe. They are those of rise of tension due to any cause, namely, headache (often paroxysmal), vomiting and, later, papillœdema. Their severity essentially depends upon the rate of rise of intra-cranial tension. If this is gradual and insidious they may at first be very slight for periods of weeks or months. Thus a case of mine due to slow occlusion of the aqueduct of Sylvius by chronic ependymitis first came under observation for failing vision secondary to papillœdema, but had never exhibited headaches or vomiting. If sudden and absolutely complete obstruction to the flow of cerebro-spinal fluid takes place, loss of consciousness and death follow rapidly. Such a case may resemble sudden intra-ventricular hæmorrhage where great rise in pulse, temperature and respiration rate are characteristic terminal signs.

In diagnosis, the ease with which the presence of hydrocephalus can be overlooked should be remembered. When its existence is proved steps must be taken to find its cause, a task which is often extremely difficult and which has led to some cases being described as "idiopathic." Certain investigations of a surgical character can, and in some cases must, be carried out to determine the presence and the type of hydrocephalus. On lumbar puncture the fluid is often under high pressure but at times the latter is sub-normal or, in an acute case of complete obstruction, a practically dry tap may be made. If a ventricular puncture be carried out simultaneously, the pressures in cerebro-spinal fluid in the ventricles and in the lumbar subarachnoid space will, granted that the patient's head and lumbar region be arranged in the same horizontal plane, be equal if the hydrocephalus is external, but the ventricular pressure will be much higher if the hydrocephalus is internal. Differentiation between the internal and external varieties by means of intra-ventricular injection of phenolsulphonephthalein has been mentioned—1 cc. of dye into the ventricle with lumbar puncture ten minutes later, when the addition of sodium hydroxide to the fluid produces a red colour in cases of external or communicating hydrocephalus. If lumbar puncture be performed with the patient in a sitting position and air be injected in place of the fluid withdrawn, an X-ray photograph of the skull (encephalography) will show air in the lateral ventricles if the hydrocephalus is communicating but not if it is internal. Ventricular puncture with measurement of the volume of fluid withdrawn (ventricular estimation) enables the presence of hydrocephalus to be proved in a doubtful case. If the volume of fluid obtained is in excess of 25 cc., dilatation of the

carried out and the blood evacuated. It must be remembered that in a high proportion of cases the hæmatoma is bilateral.

In cases of doubt ventriculography may be useful in diagnosis.

(3) *Arterio-venous Aneurysm.* This is an occasional sequel to a head injury and consists of a rupture of the internal carotid artery into the cavernous sinus. The clinical picture that results consists of œdema of the conjunctiva and eyelid, pulsating exophthalmos, signs of venous congestion in the fundus, partial or total ophthalmoplegia, and a systolic bruit audible to the patient. This bruit can be heard all over the patient's skull with a stethoscope. Rarely, the condition is produced by atheroma of the internal carotid artery leading to rupture. In two such cases under my observation spontaneous recovery slowly took place.

Fig 2977.—OXYCEPHALY. NOTE RAISED HEIGHT OF THE SKULL REACHING A MAXIMUM IN THE REGION OF THE CORONAL SUTURE.

Fig 2978.—ANTERIOR VIEW OF THE SAME PATIENT AS SHOWN IN *Fig* 2977.

Fig 2979.—OXYCEPHALY. ENLARGEMENT AND THINNING OF THE SKULL WITH INCREASED CONVOLUTIONAL MARKINGS ("BEATEN SILVER" APPEARANCE) AND RAISED VERTEX IN THE NEIGHBOURHOOD OF ANTERIOR FONTANELLE ("TOWER SKULL").

Ligature of the homolateral internal carotid artery may give great relief, though it is not free from the risk of producing hemiplegia.

(4) *Oxycephaly.* A congenital condition producing signs and symptoms in childhood consisting of a skull of distorted shape (tower-skull), exophthalmos, and signs of raised intra-cranial tension (e.g. papillœdema and secondary optic atrophy). The syndrome is the result of premature closure of the cranial sutures. When signs of raised intra-cranial tension are present a decompression should be performed.

(5) *Jacksonian Epilepsy.* This condition is due to the presence in the motor convolution of a focus of irritation. Jacksonian fits may occur at any age. Clonic contractions begin locally in some muscle-group corresponding to the affected area of the cortex and then spread to other muscle-groups on the same side of the body in the order in which they are represented on the surface of the Rolandic gyrus. The whole of one side of the body may during the course of a fit eventually be affected. When extension proceeds as far as this, consciousness is usually lost, but if the convulsions are more restricted, consciousness may be retained throughout. A familiar form is facio-brachial epilepsy, in which the arm and side of the

face on one side of the body are convulsed, with conjugate deviation of the head and eyes to the side of the lesion. *An attack of Jacksonian epilepsy may spread until* the convulsion becomes generalised and one of grand mal. The most important cause of Jacksonian epilepsy as far as the surgeon is concerned is a superficially placed neoplasm in the motor area, e.g., a meningioma. It should be remembered, however, that Jacksonian epilepsy may result from a more deeply-seated growth, such as a glioma in the substance of the hemisphere below the motor cortex. Neoplasm is, nevertheless, far from being the commonest cause of Jacksonian attacks. When these begin in childhood a small area of congenital sclerosis in the Rolandic area is the usual focus of irritation, though acquired conditions such as infantile hemiplegia may provide the underlying pathological process. At a later age, cerebral arterial degeneration is the most frequent cause, but general paralysis of the insane must be remembered. Cranial injuries in the neighbourhood of the motor cortex are, of course, also an occasional cause.

Relief may sometimes be obtained by surgical excision of an irritant focus, but success is not invariable. The surgery of generalised epileptic attacks is still more disappointing, even when these are the result of a cranial injury such as a depressed fracture. Surgical intervention probably has most success as a prophylactic measure when carried out immediately after a cranial injury and before convulsions have appeared.

CHAPTER III

Cranial Nerves

(1) *Olfactory Nerve*

The olfactory tract may be damaged in fractures of the anterior fossa of the skull or by pressure from intra-cranial tumours such as a growth in the frontal lobe, a meningioma of the olfactory groove or a pituitary adenoma. Unilateral anosmia results.

Irritation of the uncus from basal lesions may produce the characteristic "uncinate fits"—dreamy states associated with strong hallucinations of smell.

(2) *Optic Nerve.*

The appearance of swelling of the optic disc—papillœdema—is the condition in connection with this nerve which is of the most importance to surgeons (see also page 4547). Swelling of the optic disc due to rise of intra-cranial tension must be distinguished from œdema of the disc due to inflammation (optic neuritis) or to retinal arteriosclerosis. Papillœdema from raised intra-cranial tension is at first, even when considerable swelling is present, associated with little impairment of vision. Only gradually do concentric restriction of the peripheral fields of vision and enlargement of the blind spot develop. Other signs of raised intra-cranial tension such as headache, vomiting, and increased cerebro-spinal fluid pressure may be found.

Optic neuritis may be associated with exudates and hæmorrhages in the rest of the fundus, and signs of chronic nephritis or diabetes mellitus be found. When secondary to retinal atheroma the changes of the latter condition will be visible and signs of general or of cerebral atheroma be detected. Papillœdema tends to develop in conditions where the rise in intra-cranial tension is gradual and in particular when hydrocephalus is present. Thus it is frequent in intra-cranial tumour, especially when this is present below the tentorium and is obstructing the flow of cerebro-spinal fluid. When rise of intra-cranial tension is rapid, as in acute diffuse leptomeningitis, papillœdema is rare. It is often absent in cerebral abscess. The optic nerve or tract may be involved in injuries of the orbit or in gross lesions behind the eyeball or close to the chiasma or optic tract at the base of the brain, such as pituitary adenomata or the exudate of acute meningitis, that damage the fibres by pressure. Impairment of vision may thus be a sequel to an attack of acute meningococcal meningitis. Atrophy of the disc may be observed ophthalmoscopically. Optic atrophy due to primary involvement of the optic nerve fibres must be distinguished from that secondary to prolonged papillœdema. In the former, the disc margins are clear cut and the physiological cup preserved; in the latter, the cup is filled up with exudate and the disc edge is blurred.

(3) *Oculomotor Nerve* (see page 4558).

(4) *Fourth Cranial Nerve* (see page 4589).

(5) *Sixth Cranial Nerve.*

Lesions of surgical importance of these three nerves—the motor nerves to the external and internal muscles of the eyeball—are best considered together. The oculomotor nerve emerges from the internal aspect of the crus cerebri at the base of the brain and passes forwards in the outer wall of the cavernous sinus to enter the orbit through the superior orbital fissure. The 4th nerve arises from the roof of the mid-brain posterior to the corpora quadrigemina and winds downwards and forwards around the outer aspect of the crus cerebri also to pass along the outer wall of the cavernous sinus and through the superior orbital fissure to enter the orbit. The 6th nerve runs, from its point of origin on the anterior aspect of the brain-stem at the junction of the pons and medulla, a long course forwards over the base

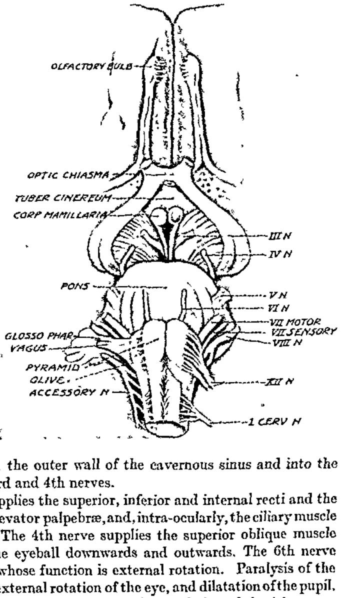

Fig. 2980.—Diagram showing the origin of the cranial nerves from the brain stem

of the skull to pass through the outer wall of the cavernous sinus and into the orbit in company with the 3rd and 4th nerves.

The oculomotor nerve supplies the superior, inferior and internal recti and the inferior oblique muscles, the levator palpebræ, and, intra-ocularly, the ciliary muscle and the sphincter pupillæ. The 4th nerve supplies the superior oblique muscle whose action is to rotate the eyeball downwards and outwards. The 6th nerve supplies the external rectus whose function is external rotation. Paralysis of the oculomotor produces ptosis, external rotation of the eye, and dilatation of the pupil. Impairment of downward and outward rotation follows a lesion of the 4th nerve, diplopia resulting when the patient looks downwards and outwards towards the side of the lesion. External strabismus results from paralysis of the 6th nerve. These three nerves are liable to be involved simultaneously by the same

lesion. Recognition of 3rd and 6th is more important than that of 4th nerve palsy.

The nerves may be damaged by lesions in the orbit such as tumour (including metastatic deposits) or inflammation. Such lesions are likely to produce external signs such as proptosis. Injuries, e.g. fractures of the orbital walls, will easily be recognisable. One or more of the nerves may be affected by a sub-acute periostitis in the sphenoidal fissure—the "syndrome of the sphenoidal fissure"—when the first division of the 5th nerve is likely also to be involved with the production of supra-orbital pain. The syndrome is usually easily recognisable, pain around and behind the orbit and on pressure upon the eyeball being, as a rule, also

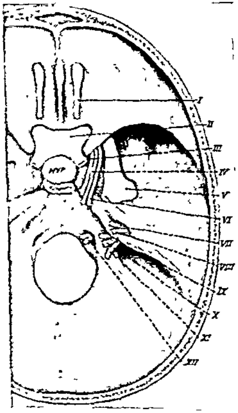

Fig 2981.—Diagram showing the points of exit of the cranial nerves from the skull.

present. Neighbouring focal sepsis such as dental or sinus infection should be looked for and eliminated. The prognosis is good though full recovery may take some months.

Tracing these three nerves posteriorly, they are involved in thrombosis and arterio-venous aneurysm of the cavernous sinus. They may occasionally be damaged by a pituitary neoplasm. Behind the cavernous sinus when they are lying at the base of the brain they become more widely separated and less likely to be involved by a single lesion.

Disease-processes that may affect them singly or together are :

(a) Acute meningitis (meningococcal, pyogenic, or tuberculous), and

(b) Meningo-vascular syphilis (gummatous meningitis) (see also page 5306).

Meningo-vascular syphilis as a cause can easily be overlooked. The onset of

the palsy is often sudden, but without treatment is persistent. Headache of moderate severity resembling that of tumour and due to rise of intra-cranial tension is often present.

(c) Meningeal neoplasm.

Signs of raised intra-cranial tension and other symptoms of neoplasm will help in diagnosis.

(d) Fractures of the base of the skull.

(e) Congenital aneurysm.

The liability of 6th nerve paralysis to occur in any condition giving rise to increased intra-cranial tension, even when the fibres of the nerve itself are not

Fig 2982.—PARALYSIS OF LEFT 3RD NERVE.

Fig 2983.—PARALYSIS OF RIGHT 6TH NERVE, SHOWING INTERNAL STRABISMUS.

directly involved by the lesion, must be remembered. Such paralysis constitutes one of Collier's "false localising signs." It is due, perhaps, to stretching of the trunk of the 6th nerve during its long course, or to downward pressure upon it.

The 6th nerve is occasionally involved in a local meningitis at the tip of the petrous portion of the temporal bone originating from otitic infection. This is "Gradenigo's syndrome."

The causes of paralysis of the 3rd, 4th and 6th nerves that we have described consist of extra-cerebral lesions. It is such lesions that are of surgical importance. The intra-cerebral causes, with the exception of cerebral tumour, are of less interest to the surgeon, but must naturally be borne in mind in differential diagnosis. They may be grouped pathologically as inflammatory, vascular, and neoplastic, and anatomically as supra-nuclear, nuclear, and infra-nuclear.

Conjugate deviation of the head and eyes may result from a supra-nuclear lesion affecting the posterior part of the second frontal convolution. If this lesion is of a destructive character, the head and eyes are deviated towards the side of the lesion; if irritative, as in facio-brachial Jacksonian epilepsy, the deviation will be convulsive or spasmodic towards the contra-lateral side.

Affection of conjugate movements is characteristic of supra-nuclear and of nuclear lesions of the motor fibres to the eye muscles. A destructive lesion of one 6th nerve nucleus will produce impairment of conjugate movement to the side of the lesion. Sometimes impairment of bilateral conjugate movements will be seen. Similar impairment follows 3rd nerve nuclear lesions which, owing to the expanded character of the nucleus, are often partial. For example, "paralysis of upward gaze" may result from pressure upon the roof of the mid-brain (as in pinealoma). Peripheral paralysis of the 3rd, 4th or 6th nerves may occur before their fibres leave the brain-stem, the lesions being, of course, distal to their nuclei of origin. That is to say, if a patient is observed to have a peripheral type of paralysis of the 3rd nerve this is not necessarily due to a lesion outside the brain. The common paralysis of this nerve in patients with cerebral arteriosclerosis is due to an intra-cerebral vascular lesion affecting the fibres after they have left the nucleus. Intra-cerebral involvement of the 6th nerve fibres distal to the nucleus or involvement of the latter itself is generally associated with ipsi-lateral facial nerve palsy owing to the intimate association of the two nuclei and of their infra-nuclear intra-cerebral fibres.

(6) *Fifth cranial nerve (Trigeminal)* (see also Vol. II, page 1829).

This nerve has certain important connections with the 7th nerve which will be described under the latter. The nerve emerges from the lateral aspect of the pons and consists of an anterior motor root and a larger posterior sensory root. The latter arises from two nuclei, one in the pons and mid-brain and the other descending into the upper cervical region of the spinal cord. Common sensation over the face is represented in this descending nucleus in inverted fashion so that a lesion of the spinal cord in the first or second segment would, if it affected the lower extremity of this nucleus, produce sensory loss in the supra-ciliary region supplied by the first or ophthalmic division of the 5th nerve.

The following are the important points to remember in connection with centrally situated pontine lesions affecting the 5th nerve nuclei:

(*a*) Lesions near the mid-line, as in syringo-bulbia, affect decussating pain and thermal fibres that cross the mid-line to ascend with the spino-thalamic tract of the opposite side. Thus such lesions produce *dissociated anæsthesia* over the face as an early sign.

(*b*) Adjacent cranial nerve nuclei, such as those of the 6th and 7th nerves, are liable to be affected simultaneously.

(*c*) The long tracts passing through the pons may also be involved, producing hemianæsthesia or hemiparesis, or both. Owing to the decussation of the long tracts in the medulla such signs will be on the side of the body opposite to the lesion, whilst the paralysis of the 5th nerve (and of any other nerves whose nuclei are simultaneously affected) will be ipsi-lateral. Thus the characteristic of intra-pontine disease is *crossed paralysis*.

Tumours and vascular lesions are among the commoner forms of pontine disease. The full symptomatology cannot be dealt with here, but the surgeon

should remember that neoplasms of the pons are likely rapidly to produce severe internal hydrocephalus.

The motor nucleus of the 5th nerve is found also in the lateral part of the pons and mid-brain. Involvement of this will produce wasting of the temporal and masseter muscles, the former resulting in hollowing of the temple and the latter in palpable wasting on clenching the teeth, together with deviation of the mandible towards the side of the paralysis. After leaving the side of the pons the 5th nerve runs a short course to the tip of the petrous portion of the temporal bone where the *Gasserian ganglion is found. Between the pons and the ganglion the nerve may* be injured in fractures of the base of the skull and involved in meningo-vascular syphilis, in meningeal exudates (acute and chronic) or by meningeal neoplasms.

Fig. 2984.—TOTAL PARALYSIS OF LEFT 5TH NERVE. DEVIATION OF MANDIBLE TO THE LEFT. NOTE CORNEAL OPACITY IN LEFT EYE RESULTING FROM NEUROPATHIC KERATITIS.

For a consideration of trigeminal neuralgia and its treatment reference should be made to Volume II, page 1829.

Tracing the 5th nerve distally, after leaving the Gasserian ganglion the fibres break up into three portions. The first, or ophthalmic division, passes forwards, close to the 3rd, 4th and 6th nerves in the outer wall of the cavernous sinus, to enter the orbit through the superior orbital fissure. It is the sensory nerve to the supra-ciliary region, to the eyeball and conjunctiva, and to the surface of the nose in a strip near the mid-line. It may be affected in fractures *of the base of the skull* or the walls of the orbit, in periostitis of the *sphenoidal fissure, gummatous meningitis, congenital aneurysm, etc., simultaneous involvement* of the 3rd, 4th and 6th *nerves being common.* When the ophthalmic division of the 5th nerve is so affected, pain in its distribution rather than anæsthesia often results and is a symptom of diagnostic importance. Paralysis of the first division may result in

the occurrence of neuropathic keratitis. The cornea becomes hazy and later ulcerated. As soon as signs of this condition appear, the edges of the eyelids should be pared and stitched together.

The second, or maxillary, division of the 5th nerve leaves the skull via the foramen rotundum and passing through the infra-orbital canal beneath the floor of the orbit reaches the face by emerging from the infra-orbital foramen. It supplies the side of the face in the upper part, the upper lip, the upper teeth, the hard palate, and the anterior part of the soft palate.

The third or mandibular, division leaves the skull by the foramen ovale to supply the lower part of the side of the face and the upper part of the pinna, the lower lip and the anterior two-thirds of the tongue. Fused with it is the anterior motor root of the 5th nerve, whilst the chorda tympani accompanies one of the branches of this division, the lingual nerve, to supply fibres of taste to the anterior two thirds of the tongue. The second and third divisions of the 5th nerve may be involved at their origin, or the Gasserian ganglion itself may be involved, by similar pathological conditions as have been described as affecting the first division.

The occasional occurrence of pain in the distribution of the 5th nerve simulating trigeminal neuralgia in disseminated sclerosis should not be forgotten.

(7) *Seventh cranial nerve* (*Facial*) (see also page 4163 and page 5131).

This is the motor nerve to the muscles of facial expression. It arises from a nucleus at the base of the dorsal part of the lower region of the pons. The fibres leaving the nucleus are in intimate association with those of the 6th nerve and emerge from the antero-lateral aspect of the pons close to its junction with the medulla. The nerve is placed internally and close to the 8th nerve, being separated from it by the pars intermedia of Wrisberg These three nerves in company pass outwards over the floor of the posterior fossa to enter the internal auditory meatus The facial nerve then enters the Fallopian canal. On reaching the internal wall of the tympanic cavity the course of the nerve is sharply backwards and then downwards until it emerges from the skull through the stylo-mastoid foramen. At this point, where it turns backwards, is situated the geniculate ganglion in which the pars intermedia ends Fibres for the secretion of saliva which have travelled from the pons with the 7th nerve leave the geniculate ganglion to join the mandibular division of the 5th. Shortly before its emergence from the stylo-mastoid foramen, the 7th nerve is joined by the chorda tympani, the fibres of which travel upwards in association with the facial nerve to the geniculate ganglion. From here they pass by the small superficial petrosal nerve to the mandibular division of the 5th nerve to ascend with the latter to the pons (to reach the fasiculus solitarius) Some taste fibres ascend in the pars intermedia, however. Within the pons the 7th nerve may be affected by lesions similar to those described under the 5th nerve. It must be remembered that the 6th nerve also is almost invariably affected. The phenomenon of "crossed paralysis," etc., as described under lesions of the 5th nerve, may also be seen

There are three forms of paralysis of the 7th nerve: (*a*) Upper motor neurone paralysis; (*b*) Lower motor neurone paralysis; (*c*) Emotional paralysis.

Upper motor neurone. This form is caused by damage to the pyramidal tracts anywhere in their course from the Rolandic area of the opposite side to the nucleus of the nerve which they reach by decussating in the pons. Such a form of facial paralysis may be seen soon after the onset in ordinary hemiplegia. It is very

incomplete in character owing to bilateral innervation of the facial muscles and consists only of some degree of weakness around the angle of the mouth. Not only this, but the weakness is perceptible only upon voluntary movements of the face. Usually it disappears upon involuntary emotional movements such as smiling. Closure of the eye and symmetrical wrinkling of the forehead will be unaffected. *Emotional paralysis* may be considered next as it is also due to supra-nuclear lesions. A patient may be seen in whom facial weakness is evident only when involuntary emotional movements such as smiling occur, but whose voluntary facial movements are normal. This is probably always due to disease of the pre-frontal area on the opposite side.

In great contrast is the picture of *lower motor neurone paralysis.* This is the form of paralysis seen in the intra-pontine disease processes already described.

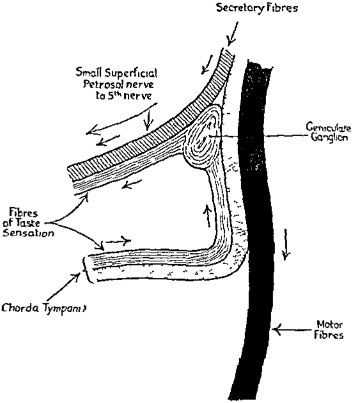

Fig 2983.—Diagram illustrating composition of the 7th nerve. (*After Bing*)

It is also produced by peripheral extra-cerebral lesions of the nerve. The loss of power in all muscles supplied by the nerve is complete. This weakness is clinically evident at first glance. The mouth is drawn over towards the normal side, the affected side of the face is smoothed out, the naso-labial groove is rendered shallow, the eye cannot be closed, and the lower lid is everted with overflow of tears down the face. Food collects between the teeth and the cheek on the paralysed side. Voluntary and emotional movements are equally involved and the affected side of the forehead cannot be wrinkled. If the facial paralysis is chronic, contractures of the muscles will eventually develop, when the face will regain some of its symmetry whilst at rest. The 7th nerve may be damaged by disease-processes during its course between the brain-stem and the internal auditory meatus. As during this course across the floor of the posterior fossa of the skull it is closely associated with the 8th nerve, the latter will be

implicated. Pathological conditions that may affect the two nerves are acoustic neurinoma, fracture of the floor of the posterior fossa, gummatous meningitis, acute meningococcal or pyogenic meningitis, or the chronic sequelæ of the former, and meningeal tumour. The sense of taste over the anterior two-thirds of the tongue on the affected side should normally be reduced, but in practice no sign of diagnostic importance is produced. The nerve may be involved during its course in its bony canal between the internal auditory meatus and the stylo-mastoid foramen inside the temporal bone. Otitic inflammation may penetrate the wall of the Fallopian canal and result in facial paralysis and, of course, the nerve may be damaged during the course of mastoidectomy. In both these two common causes the lesion affects the nerve distal to the geniculate ganglion and proximal to the point where the chorda tympani leaves. Thus, the fibres of the latter are also paralysed with loss of taste over the anterior two-thirds of the ipsi-lateral side of the tongue.

A fracture of the base of the skull that passes through the petrous portion of the temporal bone may also involve the 7th nerve during this part of its course. There is one peculiar feature of facial paralysis following upon fracture of the skull which is that such paralysis is rare as an immediate sequel to the accident. When it appears at all, it usually develops insidiously during the second week following the fracture, presumably as a result of pressure from inflammatory exudate. The prognosis is good, the palsy disappearing, as a rule, before a month has elapsed. The nerve to the stapedius leaves the facial nerve shortly before the latter emerges from the stylo-mastoid foramen. Lesions above the point of origin of this branch may produce the symptom of hyperacousis on the affected side, but in practice the appearance of this sign is variable and of little clinical value. The commonest cause of facial paralysis also involves the nerve during its bony course shortly before it reaches the stylo-mastoid foramen. The nerve is liable in this region to be damaged by acute inflammation, the onset of which is commonly preceded by exposure of the face to a cold draught. The inflammatory process is thought to be either a periostitis of the wall of the bony canal or a neuritis of the nerve. Whichever it is, the latter, situated in a confined space with no room for expansion, is immediately compressed and paralysed. The condition is known as Bell's palsy. Frequently, the facial weakness is first noticed on waking in the morning, and often, pain in the ear or over the mastoid may be experienced just before and just after the onset of the palsy. The history of onset, possibly including that of exposure to cold together with absence of evidence of otitic inflammation, differentiates the condition from facial paralysis secondary to ear disease. Involvement of the chorda tympani is common.

The prognosis of Bell's palsy is variable. If improvement is noticed during the first few weeks, recovery will probably be complete in three or four weeks. Absence of the reaction of degeneration in the affected muscles implies rapid recovery, but partial or complete reaction of degeneration means a period of months or even a year or more of paralysis. If, fourteen to twenty-one days after the onset, alteration of the normal electrical reactions is found, then *treatment to maintain* the muscles in good condition must be instituted. Stretching must be prevented by the wearing of a stirrup made of stiff wire covered with rubber tubing hooked over the ear and into the corner of the mouth to support the latter. Galvanic stimulation should be given daily. If no recovery has taken place after twelve to eighteen months, if the reaction of degeneration is present and the muscles

are in good condition, the operation of facial anastomosis, e.g. facio-hypoglossal, may be considered.

After it has left the stylo-mastoid foramen the facial nerve may be damaged by lesions in the neck and face such as injuries of the latter or diseases of the parotid gland. Taste will be unaffected. Chronic spasm of the facial muscles is sometimes seen and is probably due to chronic irritative inflammatory lesions affecting the nerve trunk. If troublesome and intractable it may be dealt with by alcohol injection of the 7th nerve outside the stylo-mastoid foramen.

(8) *Eighth cranial nerve* (*Auditory*).

This nerve comprises two portions, the auditory nerve whose fibres arise from the spiral ganglion in the cochlea and carry the impulses of hearing to the brain, and the vestibular nerve which originates in the ganglion of Scarpa and whose

Fig. 2986.—Lower motor neurone facial palsy (left), secondary to malignant growth in the retro-parotid space.

fibres, supplying the semicircular canals, the utricle and the saccule, transmit to the brain impulses of postural sensibility, giving knowledge of the position of the head in space and assisting in the preservation of equilibrium.

The signs and symptoms of affection of these two portions of the 8th nerve are as follows:

Auditory.—(*a*) Nerve deafness. (*b*) Tinnitus.

Vestibular.—(*a*) Vertigo. (*b*) Nystagmus. (*c*) Forced movements. (*d*) Falling and deviation of gait. (*e*) Pass-pointing.

The 8th nerve, its two portions united into one trunk, leaves the internal ear by emerging from the internal auditory meatus and passes to the external aspect of the lower border of the pons in company with the 7th nerve, separated from the latter by the pars intermedia.

The nuclear arrangements of the two divisions of the nerve in the brain-stem are complex. Free decussation takes place between the nuclei of the auditory division and their fellow nuclei of the opposite side. Fibres then ascend from them

as the lateral fillet to carry impulses of hearing to the temporal cortex. The nuclei of the vestibular division are connected to: (*a*) The cerebellum; (*b*) the oculomotor nuclei; (*c*) the motor fibres from the spinal cord to the muscles; and (*d*) the red nucleus and cerebral cortex.

The 8th nerve may be involved in disease-processes affecting: (*a*) The internal ear and petrous portion of temporal bone; (*b*) The floor of the posterior fossa; and (*c*) The pons varolii.

The internal ear may be damaged by: (*a*) Acute or chronic inflammation. Acute labyrinthitis Spread infection in acute meningitis or in acute or chronic otitis media. (*b*) Vascular lesions. Hæmorrhage in hyperpiesis. Atheroma of the vessels supplying the labyrinth, with impoverishment of its blood supply. (*c*) Drugs, e g. quinine and salicylates. (*d*) Otosclerosis. (*e*) Fractures of the base of the skull.

The nerve in the floor of the posterior fossa may be involved in: (*a*) Acoustic neurinoma. (*b*) Acute or chronic meningeal inflammation. Meningococcal meningitis. Meningo-vascular syphilis. (*c*) Fracture of the base of the skull.

Within the brain-stem the nuclei and their fibres may be affected by vascular lesions, neoplasms, encephalitis, etc. Occasionally symptoms of vertigo result from such central lesions, but they are rare and of little clinical importance. Similarly, owing to the free decussation, deafness from central lesions is very seldom observed. Theoretically it should be produced by bilateral disease of the temporal cortex, the rarity of which is obvious.

The following conditions may result from lesions affecting the internal ear: Nerve deafness, tinnitus, vertigo, and other signs of vestibular irritation such as nystagmus, as already mentioned. The causes of involvement of the two divisions of the 8th nerve in the internal ear are many and varied, and those of surgical importance have to be distinguished from the remainder. One of the commonest syndromes seen in practice is that of deafness, tinnitus and vertigo developing in a patient who has long been a sufferer from chronic purulent or catarrhal otitis media. The deafness in such a case may have preceded the tinnitus and vertigo for a long time and may be middle-ear rather than nerve deafness, or of a mixed character. The type of deafness is determined by the tuning fork tests.

Rinne's Test (see page 4607).

Weber's Test (see page 4607).

In the common condition that we are describing, tinnitus is usually constant and, whether high or low pitched in character, may be severe enough to make life almost unbearable. Vertigo is not always present, but when it appears it is paroxysmal. It may be slight, or intense enough to produce vomiting or to throw the patient to the ground with violence.

In otitis media these symptoms are often partly due to functional disturbance of labyrinthine activity as distinct from organic involvement of the internal ear, and when this is the case relief may be obtained by cure of the otitis media or in chronic cases by Eustachian inflation. Another common syndrome that needs distinguishing from the one due to chronic otitis is that of tinnitus and vertigo due to circulatory changes in the labyrinth. It is seen in patients past middle age with signs of general or cerebral arteriosclerosis, and possibly, but not necessarily, with hyperpiesis. Tinnitus and vertigo are more prominent symptoms than nerve-deafness. Vertigo only may be present. An allied condition which is usually

overlooked and which is one that should always be borne in mind is that of vertigo in young adults associated with functional hypopiesis. Paroxysmal vertigo is experienced and the systolic blood-pressure is found to be sub-normal, often below 100 mm.Hg., although the patient is free from serious organic disease. He is, however, generally of a nervous disposition. Less frequently acute labyrinthitis is seen. It may occur secondary to otitis media, to acute meningococcal meningitis, in acute general infections, or may appear idiopathically. Nerve-deafness, tinnitus and vertigo are severe in character and rapid in onset. The vertigo may last continuously for hours or days, when the least movement of the patient's head may result in increase of the symptom and in vomiting. During the paroxysm the sufferer may be thrown violently to the ground to the side of the lesion, exhibit forced movement to the same side, and vomit. On examination, deviation in gait and pass-pointing towards the affected side may be found, together with lateral or rotatory nystagmus with the slow movement of the eyeballs towards this side. The patient may feel himself falling to the opposite side. The paroxysm may be prolonged or brief and momentary. Deafness and tinnitus may occasionally be seen in toxic affection of the labyrinth as in overdosage with quinine and salicylates and, rarely, from tobacco and alcohol.

Nerve-deafness may be hereditary from under-development of the inner ear or may result in early life from congenital syphilis. It may follow fracture of the skull passing through the petrous portion of the temporal bone, or long exposure to extreme noise as in boilermakers and rivetters. Simulation by hysterical deafness should not be forgotten. In the posterior fossa of the skull tinnitus and nerve-deafness may be produced by the lesions to which the 8th nerve is liable in this part of its course. Tinnitus is the usual initial symptom in auditory neurinoma, and nerve-deafness follows later. The other common pathological conditions in this region have been mentioned. They are fracture, and acute and chronic meningitis, including gummatous meningitis. Whatever the disease-process, characteristic of involvement of the 8th nerve in the posterior fossa is simultaneous damage to the facial nerve with the production of facial paralysis. Signs of raised intra-cranial tension, and of pressure upon the cerebellum and brain-stem and upon other cranial nerves such as the 5th, may be seen in lesions in this neighbourhood (see Tumour of the cerebello-pontine angle, Vol. II, page 1790).

Operative measures are occasionally employed for the relief of severe and intractable tinnitus. The trunk of the 8th nerve may be cut in the posterior fossa or the labyrinth be destroyed or injected with alcohol. The patient may prefer total deafness to the torture of the tinnitus. Medicinally, sedatives often give much relief, and luminal ($\frac{1}{2}$ to 1 gr. t.d.s.) frequently acts like a specific.

(9) *Ninth cranial nerve (Glosso-pharyngeal).*

This emerges from the lateral aspect of the medulla between the olive and restiform body and, passing over the floor of the posterior fossa of the skull, leaves the latter via the jugular foramen in close association with the vagus and spinal accessory nerves. It enters the neck in the retro-parotid space whence it curves forward to reach its destination. The nerve is mixed, containing motor, sensory and visceral fibres. The latter supply secretory neurones to the parotid gland and fibres of taste to the posterior third of the tongue. Sensation is conveyed from the posterior part of the soft palate, the tonsils and fauces, and the upper part of the pharynx. The glosso-pharyngeal is very seldom the subject of isolated

paralysis. It is more often involved in company with other nerves and structures. Lesions affecting it may be situated in the brain above its motor nucleus (supranuclear lesions), at the level of the nucleus, in the posterior fossa of the skull outside the medulla, in the immediate neighbourhood of the jugular foramen, or in the retro-parotid space outside the cranium.

Signs of paralysis of the nerve consist of anæsthesia of the faucial region and of the posterior third of the tongue, loss of taste over the posterior part of the latter, loss of the palatal reflex, and deviation of the uvula.

The types of pathological process that may affect the nerve consist of:

(a) Intra-medullary lesions such as thrombosis, progressive bulbar paralysis, neoplasm, and syringo-bulbia. Signs of damage to other medullary structures will overshadow the picture.

(b) Neoplasms, gummatous meningitis, tuberculosis, fracture, etc., in the posterior fossa of the skull. The 10th, 11th and, possibly, the 12th nerves are likely to be affected in company.

(c) The same group of nerves, together with the cervical sympathetic, are likely to be affected in disease of the retro-parotid space.

Glosso-pharyngeal Neuralgia.

This is an uncommon form of neuralgia affecting the 9th cranial nerve, with clinical characteristics similar to trigeminal neuralgia. Pain develops in the tonsil and neighbouring faucial and pharyngeal region and radiates through the side of the neck behind the ascending ramus of the mandible towards the ear. It is very apt to be mistaken for trigeminal neuralgia. The pain is commonly excited by stimulation of the tonsil, as in eating, and may sometimes be abolished when the tonsil is anæsthetised—a point of diagnostic value (Wechsler). Harris has successfully injected the glosso-pharyngeal with alcohol, but this is an uncertain procedure. Severe neuralgia is probably best treated by performing craniotomy and severing the nerve in the posterior fossa of the skull (Adson; Jefferson). Before diagnosing this form of neuralgia, it is important to exclude organic disease such as neoplasm of the tonsil.

(10) *Tenth cranial nerve (Vagus).*

This is a mixed nerve composed of motor, sensory and visceral branches. *It emerges from the lateral aspect of the medulla between the olive and the restiform* body immediately below the glosso-pharyngeal and spinal accessory nerves. It supplies fibres of common sensation to the posterior part of the pinna and to part of the external auditory meatus. After entering the neck, it runs downwards in the carotid sheath between the internal carotid artery and the jugular vein and gives off its superior laryngeal branch, which supplies fibres of sensation to the larynx and epiglottis and motor fibres to the crico-thyroid muscle. Continuing in its course into the thorax and abdomen, it gives off its recurrent laryngeal branch. On the right side, this hooks back round the subclavian artery to reach the larynx deep to the thyroid gland; on the left side, this branch follows a similar course after hooking round the arch of the aorta. The recurrent laryngeal supplies motor fibres to all the laryngeal muscles except the crico-thyroid.

The vagus supplies visceral fibres to the intra-thoracic and intra-abdominal viscera which act in functional antagonism to those of the sympathetic system.

The causes of paralysis of the vagus inside the brain and cranium and in the upper part of the neck are the same as in the case of the glosso-pharyngeal and,

similarly to the latter, other nerves and structures, especially the 9th and 11th nerves, are likely also to be affected.

The recurrent laryngeal branches are commonly damaged by intra-thoracic disease-processes, especially the left branch by aneurysm of the aorta.

In paralysis of the vagus high up in its course, above the origin of the superior laryngeal branch, there will be anæsthesia and paralysis on one side of the soft palate and pharynx (through the pharyngeal plexus) and of the larynx. There will be difficulty in speaking and swallowing and the voice will be nasal. Respiration may be impeded and the vocal cord on the affected side will be immobile in the cadaveric position.

Paralysis of the recurrent laryngeal produces hoarseness of voice and, some-

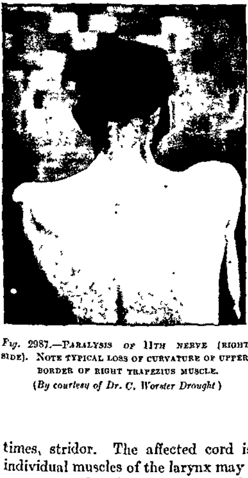

Fig. 2987.—Paralysis of 11th nerve (right side). Note typical loss of curvature of upper border of right trapezius muscle.
(*By courtesy of Dr. C. Worster Drought*)

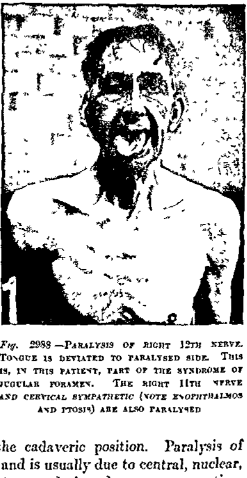

Fig. 2988.—Paralysis of right 12th nerve. Tongue is deviated to paralysed side. This is, in this patient, part of the syndrome of jugular foramen. The right 11th nerve and cervical sympathetic (note enophthalmos and ptosis) are also paralysed

times, stridor. The affected cord is in the cadaveric position. Paralysis of individual muscles of the larynx may occur and is usually due to central, nuclear, or supra-nuclear lesions. Unilateral abductor paralysis: dyspnœa on exertion. The vocal cord is in the mid-line. Bilateral abductor paralysis: difficulty in inspiration is severe and may end fatally. Both cords tend to meet in the mid-line. Bilateral adductor paralysis: speech is much impaired, but respiration is unaffected. This condition is commonly hysterical. Bilateral recurrent paralysis: speech is impossible and there is much respiratory difficulty with stridor. Total bilateral vagus paralysis is a rapidly fatal condition. There is laryngeal paralysis, with difficulty in breathing and inability to speak, cardiac irregularity, and symptoms of visceral pain and vomiting consequent upon atony and dilatation of the stomach.

Slow pulse and spasm of the larynx may occur in irritation of the vagus prior to paralysis.

Apart from the disease-processes mentioned, the vagus is liable to be affected to some degree in diphtheritic neuritis, in other forms of polyneuritis, and in neoplasms and operations in the neck.

Obviously, with laryngeal anæsthesia, care in feeding is necessary to avoid aspiration pneumonia, and tube-feeding may be essential.

In investigating any case of possible vagal palsy, laryngoscopic examination is essential.

(11) *Eleventh cranial nerve (Spinal Accessory)* (see also page 4168).

This nerve is composed of two portions, a medullary part, the fibres of which leave the lateral aspect of the medulla immediately below those of the vagus, and a spinal part, which is formed by branches springing from the anterior horns of the first four or five cervical segments and emerging from the lateral aspect of the spinal cord. These branches unite outside the spinal cord and ascend into the cranium via the foramen magnum to join the medullary portion of the nerve. The trunk formed by this union passes across the posterior fossa of the skull to emerge in the retro-parotid space through the jugular foramen in company with the 9th and 10th nerves. The medullary fibres of the spinal accessory are really part of the vagus, for they have the same nuclear origin, and as soon as the spinal accessory has left the skull they branch off to join the vagus. The remainder of the spinal accessory supplies the sterno-mastoid and trapezius with motor fibres.

Paralysis of the nerve is due to the same causes as those enumerated under the glosso-pharyngeal, and paralysis of the latter and of the vagus commonly occurs simultaneously. Paralysis of the sterno-mastoid is shown by obvious wasting, by inability to turn the head to the side opposite to the lesion, and by deviation of the head to the paralysed side on forcible flexion of the chin against resistance. Paralysis of the trapezius causes loss of the normal curvature of the neck with inability to shrug the shoulders properly. Some downward and inward displacement of the scapula may be seen.

(12) *Twelfth cranial nerve (Hypoglossal)*.

This nerve leaves the lateral aspect of the medulla anterior to the olive, between the latter and the pyramid. After passing across the posterior fossa, it leaves the skull by the anterior condylar foramen to enter the retro-parotid space. It passes downwards in the neck close to the vagus, between the internal carotid artery and the jugular vein, as far as the angle of the mandible, where it turns inwards to its destination to supply the muscles of the tongue. The causes of paralysis are the same as for the glosso-pharyngeal nerve. Lower motor neurone or nuclear paralysis produces wasting of the affected half of the tongue with deviation to the side of the lesion on protrusion. Frequently, fibrillary tremors may be seen. Supra-nuclear lesions, as in ordinary hemiplegia, result in some deviation of the tongue, but there is no wasting of the muscles.

Syndrome of the Jugular Foramen (Vernet).

This clinical picture results from gross lesions in the neighbourhood of the jugular foramen, e.g. meningioma, gumma, tuberculosis, or injury such as fracture of the posterior fossa or gunshot wound. The same syndrome results from disease or injury in the retro-parotid space where the cervical sympathetic and hypoglossal nerves are also liable to be involved. The signs and symptoms are those of a unilateral paralysis of all the nerves affected.

CHAPTER IV

Spinal Cord and Peripheral Nerves

INJURIES

The spinal cord may be contused as a result of blows upon the spinal column and be followed by signs and symptoms below the level of the injury of a variable degree of severity dependent upon the amount of damage to the cord. The symptoms may be transient or permanent. Rarely, the cord may be lacerated in a penetrating wound. A blow upon or wrenching of the spinal column, or hyper-extension of the head may be followed by hæmorrhage inside the spinal cord itself although no gross damage may have been done to the vertebræ. This occurrence—hæmatomyelia—appears to be commonest in young adults, and nearly always takes place in the cervical enlargement. The bleeding is situated near the centre of the cord and may spread through several segments. It may be confined to one side only of the cord—hemi-hæmatomyelia.

The signs produced by the hæmorrhage are of two types: (1) those found at the level of the lesion, and (2) those below the level. At the level of the lesion may be found a zone of hyperæsthesia together with weakness and, later, atrophy of muscles supplied by the affected segments. As the cervical enlargement is nearly always the seat of damage these signs will be found in the arms or, if the lesion be unilateral, in the ipsi-lateral arm. If the hæmorrhage is high up in the cervical enlargement and affects segments C5 or C6, palsy of the spinati, deltoid, biceps and supinator longus muscles may be found. If segments C7, C8 and D1 are damaged, the muscular weakness will be of the intrinsic muscles of the hands and of the flexor muscles of the wrist and fingers. Horner's syndrome—enophthalmos, miosis of the pupil, ptosis, and absence of sweating on the affected side of the face—may be seen in this lower type of injury from involvement of the cervical sympathetic fibres (see fig. 2988). Immediately below the level of the lesion, over an area of skin corresponding to several segments, loss of pain and thermal sensation may be found from damage to decussating spino-thalamic fibres. If the hæmorrhage is more extensive, a varying degree of damage to the long ascending and descending tracts of the cord may result with the production of anæsthesia, paraplegia, sphincter paralysis, etc. Hemi-hæmatomyelia produces the Brown-Séquard syndrome. There will be flaccid paralysis of the muscles of the arm on the side of the lesion supplied by the damaged segments, and a zone of hyperæsthesia on the same side over the skin supplied by these segments. Below the level of the lesion and on the same side of the body will be found slight diminution in sensation to light touch and, perhaps, a little diminution in deep sensibility. On the same side, pyramidal weakness in the leg with spasticity, exaggerated deep reflexes and extensor plantar response and, on the opposite side, loss of pain and thermal sensation with preservation of light touch and of deep sensation will be seen. The cases of hæmatomyelia that I have seen have all been due to accidents in which a violent throwing of the body for some distance took place. In two cases a fracture of a transverse process was observed radiographically.

The treatment of spinal contusion and of hæmatomyelia is conservative, and progressive improvement in symptoms is to be expected although permanent residual damage probably always remains after hæmatomyelia and sometimes after contusion.

The spinal cord may be damaged in fracture—dislocation of the spinal column. This is commonest in the lower cervical and dorso-lumbar regions, the trauma producing it often being a fall from a height on to the feet, or heavy pressure or a blow on the back which produces forcible bending of the spine. The injury to the *spinal cord may be slight or incomplete, or consist of complete transection.*

After the lower cervical and dorso-lumbar regions, fracture-dislocation occurs most often in the upper cervical spine. Simple dislocation of one or both articular processes may also be seen at this level. The odontoid process may be dislocated forwards. Sudden death is frequent when the injury involves the upper cervical vertebra or, if not sudden, it may rapidly supervene from paralysis of external

Fig. 2989.—Fracture of 6th cervical vertebra. Hemi-hæmatomyelia with Brown-Séquard's syndrome resulted
(*Southend General Hospital.*)

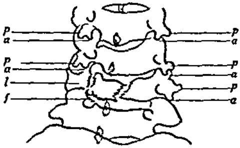

Fig. 2990.—Fracture of 6th cervical vertebra

(*p*) Posterior tubercle of pedicle.
(*a*) Anterior tubercle of pedicle.
(*l*) Articular process fractured at junction with pedicle body.
(*f*) Pedicle fractured and displaced, possibly injuring the nerve in the groove and the artery in the foramen.

respiration due to involvement of the phrenic nerves or from medullary shock. *Marked hypothermia is said sometimes to be seen.*

Laminectomy may be of therapeutic value in certain cases of injury to the vertebral column, e.g. in pure dislocation in the cervical region, in causes of pushed-in fracture of the dorsal laminæ where no dislocation is present, in fracture-dislocation below the border of the 1st lumbar vertebra where the cauda equina (the fibres of which are capable of regeneration) only will be affected, and in long-standing cases where symptoms get worse as a result of slow organisation of blood clot and the formation of adhesions.

Paraplegia.

Conveniently under this heading may be considered the signs of damage to the cord from injuries and also the other causes of spinal cord disease of interest to the surgeon. Paraplegia is produced by any disease-process that injuries the pyramidal tracts in the spinal cord. This disease-process may be extra-dural or intra-dural. If intra-dural it may either be extra- or intra-medullary. The chief extra-dural lesions affecting the spinal cord are fracture-dislocation of the spinal column, tuberculous osteitis, and secondary deposits of malignant growth. Less

important are bony growths of spondylitis deformans, Paget's disease, osteoma, myeloma, etc. Of the intra-dural processes, syphilitic pachymeningitis, meningitis serosa circumscripta, hydatid cyst, leukæmic deposits, and tumour of the meninges should be remembered. Disease of the spinal column or of the meninges affects the spinal cord by pressure, producing the syndrome of spinal compression.

Of the intra-medullary causes of paraplegia that are of interest to surgery neoplasm is the most important. Hæmatomyelia has already been described.

A paraplegia when fully established consists of one of two types—paraplegia in extension or paraplegia in flexion. In the former, which is the commoner, the legs are in a state of hypertonus in extension. The plantar reflexes give the upturning sign, the knee- and ankle-jerks are exaggerated, ankle and patellar clonus may be present and the abdominal reflexes will be absent. The rigidity in the legs has a peculiar quality. On passive flexion of the limbs the hypertonus is at its greatest at the beginning, and as flexion proceeds it grows less and less, like the opening of a clasp-knife—the so-called "clasp-knife" rigidity which differs from the plastic "cog-wheel" hypertonus of extra-pyramidal rigidity.

Fig 2991.—Paraplegia in flexion Note severe adduction spasm

Sphincter paralysis is likely to be present in some degree varying from precipitancy to retention with overflow or to the automatic bladder. Paraplegia in extension is thought to be due to paralysis of the pyramidal tracts, with preservation of the extra-pyramidal motor fibres.

Paraplegia in flexion is found when the damage to the spinal cord is greater and the extra-pyramidal tracts (the vestibulo-spinal tracts, perhaps, in particular) are also affected. In this condition the legs when at rest may lie in a flaccid state, but upon the slightest stimulus, such as touching them or trying to elicit a plantar reflex, they go into violent flexion spasm so that the heels may almost touch the glutei. Evacuation of the bowels and bladder may occur simultaneously—the "mass reflex." As the condition grows more severe the legs may develop permanent tonic spasm in flexion and, frequently, in adduction as well.

Treatment of Paraplegia.

The nursing of the patient is of great importance when paraplegia has developed. Experience has shown that, if sufficient care in treatment is given, freedom from complications can often be maintained indefinitely.

The first step is to prevent the formation of bedsores (see also Vol. I, page 1249). These are most likely to develop over the bony prominences. The patient should be on a water-bed and he should not be left too long in one position. The skin over

the back of the trunk and legs should, after washing, be rubbed with methylated spirits daily and dried. The tuber ischii, greater trochanters, heels, etc., should be suitably supported by soft pillows.

Secondly, efforts must be made to avert infection of the urinary tract during the period of retention and overflow which develops immediately after the appearance of paraplegia and which lasts for about three weeks if the patient's general condition remains good, but for longer if this becomes poor, before the automatic bladder begins to function. The usual practice is to prevent any undue distension of the bladder by daily catheterisation or by tying in a catheter for two or three days at a time, being extremely careful in taking aseptic precautions. In spite of this, however, urinary infection is very liable to occur. If cystitis develops, it must be treated by daily irrigation, e.g. with 1 in 4000 oxycyanide of mercury if the urine is alkaline, or if acid and if the infecting organism is the bacillus coli with 1 in 2000 potassium permanganate. Permanent suprapubic drainage may become necessary.

Spinal Compression.

The signs and symptoms of this condition, due to the causes already mentioned, are those of paraplegia together with those resulting from damage to parts of the spinal cord other than the pyramidal tracts. Sensory changes and atrophic paralysis of muscles are to be looked for. The findings in the cerebro-spinal fluid, except in the very earliest stages of compression, are characteristic and of the greatest diagnostic value.

The total protein content is much raised—0·1 per cent or higher. The fluid may be a golden colour (xanthochromia). If the protein content is very high, spontaneous clotting may take place. These changes in the cerebro-spinal fluid are known as Froin's syndrome and are probably due to occlusion by the compressing lesion of veins draining blood from the cord and meninges. Compression of the cord in the upper cervical region is likely, as already mentioned, to result in sudden death.

In the lower cervical region the cervical enlargement will be affected, and flaccid paralysis with the development later of atrophy of some of the muscles of the arms will appear. If the upper segments of the cervical enlargement are involved the paralysis will affect the deltoid, biceps and supinator longus, whilst in damage to the lower segments the muscles concerned will be the intrinsic muscles of the hands and the flexors of the wrist.

In any disease-process compressing the spinal cord from without, the posterior nerve roots are frequently irritated with the production of pains over the area of skin supplied by the affected segments of the cord—"root pains." The presence of these is of great diagnostic importance in discriminating between compression of the spinal cord as distinct from paraplegia due, for instance, to intra-medullary degenerative or inflammatory lesions involving the pyramidal tracts.

In the case of compression affecting the cervical enlargement the root pains will be in the arms. In a case of mine of a woman whose breast had been removed for carcinoma a year or two previously, vertebral metastases first showed themselves by the development of severe pains running down the outer aspects of the arms in the distribution of the segments C5 and C6. With a progressive lesion as the cause of compression the root pains will eventually be replaced by anæsthesia. In addition to the presence of root pains, a zone of hyperæsthesia may be found over

the segmental distribution at the level of the lesion. Below this level will be found complete anæsthesia over the trunk and lower limbs, together with spastic paraplegia.

The signs and symptoms are, of course, those of spinal compression of advanced degree when the picture of complete or virtually complete transection of the cord is seen. But when the patient first comes under observation his condition may be of any stage of severity from early root pains or slight weakness of limbs to signs of complete transection of the cord.

In the dorsal region (the commonest site for tuberculous caries) the zone of hyperæsthesia and root pains, if present, will form a band like a girdle over the distribution of the intercostal nerves from the affected segments and, immediately below this, anæsthesia of the trunk and legs will be found. Characteristic of dorsal compression is the upper "level" of sensory change which, when found, is of diagnostic value in discriminating between conditions produced by a single local lesion of the cord and other disease-processes, such as sub-acute combined degeneration, which involve the tracts of grey matter widely and do not concern the surgeon, but which also produce sensory losses and paraplegic signs and may simulate spinal compression.

In deciding which segments of the cord in the dorsal region are affected by the lesion it is useful to remember that the intercostal nerves from segment D4 supply the level of the nipples, and those from D9 the level of the umbilicus. Not only is the finding of an upper level of sensory change of value in diagnosing the presence of local lesion of the spinal cord in the dorsal region, but it also enables a decision to be made as to which are the uppermost segments involved by the compressing lesion. It is usual to-day, in fact, to determine the segmental level of the disease for the purpose of laminectomy by clinical means alone if these sensory signs are present, and only to employ lipiodol radiography if they are absent. Lipiodol is thought to have a slightly irritant action.

One important point should be borne in mind in diagnosing spinal compression. In slowly progressive lesions, and particularly in tuberculous caries, signs of pyramidal damage often appear first, before root pains and sensory loss, so that a pure motor paraplegia, perhaps of insidious onset, is the earliest sign. It is very easy in such a case to consider the paraplegia as due to some degenerative or inflammatory process affecting the pyramidal tracts, such as disseminated sclerosis or motor neurone disease, and as of no importance to the surgeon.

One of my cases was a middle-aged woman with a well-marked paraplegia of insidious onset and with no sensory changes whatever. However, lumbar puncture revealed a moderately raised protein percentage, and lipiodol was held up in the mid-dorsal region. Her condition was one of spinal compression due to spondylitis deformans for which laminectomy was indicated.

Lipiodol radiography is performed as follows: Cisternal puncture is carried out either with a small lumbar puncture needle or with a special needle graduated in centimetres. After anæsthetising the skin with novocaine, the needle is inserted in the mid-line immediately above the spine of the axis vertebra. It is pushed forwards in the line made by joining the external auditory meatus with the nasion. The patient may be either lying on his side or sitting upright with his head well flexed forwards. The subarachnoid space may be entered anywhere between 3 and 6 centimetres below the surface. The needle should not be pushed deeper

than 6 centimetres. Entry into the subarachnoid space may be felt by the sudden lessening of resistance, but it is helpful to remove the stilette from the needle as soon as the skin is punctured. One or two cc. of lipiodol (40 per cent iodine) are slowly injected and, after the patient has remained upright for from fifteen to twenty minutes, radiography of the spinal column is carried out. Light lipiodol, which floats in cerebro-spinal fluid, may be injected by means of lumbar puncture below the level of the compressing lesion and the lower border of the latter defined, or heavy lipiodol may be injected and the patient's hips be raised in the X-ray room so that the injected fluid runs upwards to the lower level of the lesion.

After the segmental level of the disease-process has been found, it is necessary before carrying out laminectomy to determine the relationship of the under-

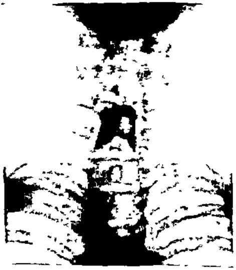

Fig. 2992.—Spinal block revealed by lipiodol. Skiagram taken three days after injection. Tumour of lower cervical cord.

Fig. 2993.—Lipiodol held up in scattered fashion by widespread meningeal growth in lower dorsal and upper lumbar regions.

lying affected segments of the cord to the overlying vertebræ. The following table is of practical value in this connection :

To ascertain which spinal segment is related to a given vertebra—

For the cervical vertebræ, add 1.

For dorsal 1–6, add 2.

For dorsal 7–9, add 3.

The 10th dorsal arch overlies lumbar 1 and 2 segments.

The 11th dorsal arch overlies lumbar 3 and 4.

The 12th dorsal arch overlies lumbar 5.

The 1st lumbar arch overlies the sacral and coccygeal segments.

(Russell Brain.)

In the lower dorsal region of the spinal column a compressing lesion will affect the lumbar enlargement of the cord. If lumbar 3 and 4 segments are involved, flaccid paralysis of the quadriceps will result together with abolition of the knee-

jerks and, later, with wasting. The rest of the muscles in the legs will show pyramidal or spastic paralysis with hypertonus. Destruction of the first and second sacral segments of the cord produces spastic paralysis of the hamstrings with flaccid paralysis of the calf muscles. Flexion of the hips, extension of the knees and dorsiflexion of the feet are unaffected. Involvement of the lower sacral segments paralyses the bladder and rectum causing retention of urine and fæces. Motor or sensory function in the legs is unaltered. Below the level of the lower border of the 1st lumbar vertebra a compressing lesion involves the fibres of the cauda equina. No spastic paralysis is seen in the legs, all muscular weakness produced being of the flaccid type with supervening atrophy. What muscles are paralysed is dependent upon what fibres of the cauda equina are affected. The calf muscles, hamstrings and glutei are often involved. Sensory loss is variable. Both in lesions of the sacral segments of the cord and of the cauda equina loss of sensation over a saddle-shaped area on the buttocks is common. The bladder and rectum may be paralysed, as in sacral lesions, or may be unaffected. Severe root pains often characterise cauda equina lesions.

DISEASE-PROCESSES PRODUCING SPINAL COMPRESSION

(1) *Spinal tumour.*

This has been considered in Volume II, page 1848.

(2) *Tuberculous osteitis.*

This has recently been classified by Butler into three types: (*a*) Early onset and mild; (*b*) Early onset and severe; and (*c*) Late onset.

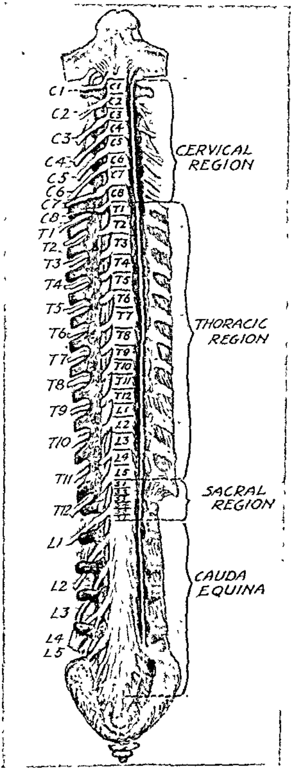

Fig 2931.—DIAGRAM OF SPINAL CORD, SHOWING THE RELATIONSHIP OF THE SPINAL SEGMENTS TO THE VERTEBRÆ AND TO THE SPINAL NERVE ROOTS AT DIFFERENT LEVELS.

Tuberculous caries nearly always develops before the age of twelve years, and about 10 per cent of cases develop spinal compression with paraplegia. Butler finds that with ordinary conservative treatment spinal compression disappears with clearing up of the paraplegia in cases of Type (*a*), though full recovery may take years. If, however, complete paraplegia exists for more than six months recovery is unlikely. Cases of Type (*b*) do not recover. Paraplegia is produced in Pott's disease by one of the three following causes: (i) Pressure upon spinal veins with œdema of the cord; (ii) Pressure upon the cord by a cord abscess; or (iii) Pinching of the cord in bony dislocation.

Type (*c*) cases are due to chronic interference with blood supply to the cord by affection of the extra-dural blood-vessels. Early treatment by the usual conservative measures results in complete recovery from spinal compression in 60 to 90 per cent of cases. The prognosis of incomplete paraplegia is extremely good.

Costo-transversectomy for drainage of a cord abscess in Type (*b*) cases is probably the best treatment. Paraplegia persisting for more than six months or changing suddenly in severity may be relieved by laminectomy.

(3) *Secondary deposits.*

These are common from hidden primary growths such as carcinoma of the prostate, breast or thyroid. Treatment is purely palliative and consists chiefly of adequate doses of morphia.

(4) *Pachymeningitis, chronic arachnoiditis, etc.*

Laminectomy in the earliest stages of these conditions may be of great benefit but is useless if deferred until spinal compression is well established.

(5) *Syringomyelia.*

This disease has at times been treated surgically by laminectomy and aspiration of fluid from the cysts. Improvement and cessation of deterioration have been reported. Most authorities, however, regard the benefit of this procedure as doubtful and consider deep X-ray therapy to be the best treatment.

(6) *Herpes zoster.*

Surgeons should remember that this condition may be due to damage to the posterior nerve roots by disease-processes such as those giving rise to spinal compression. I have seen it in spondylitis deformans.

(7) *Acute anterior poliomyelitis.*

The differential diagnosis of paralysis due to this disease when seen long after the acute attack and when surgical treatment may be desirable is important. It must be differentiated from the wasting of peroneal muscular atrophy, progressive muscular atrophy, myopathy, syringomyelia and peripheral neuritis. In the first named and in myopathy a family history may be obtainable. Their distribution is symmetrical. The wasting of poliomyelitis is stationary and often very asymmetrical. A history of the acute attack should be sought for. In syringomyelia and peripheral neuritis the sensory changes will clarify the diagnosis, though the presence of subjective unpleasant sensations secondary to vascular congestion and to coldness of the limb in old anterior poliomyelitis should be remembered.

PERIPHERAL NERVOUS SYSTEM

(1) *Interstitial neuritis.*

Two forms of this may require the attention of the surgeon. One is interstitial neuritis of the ulnar nerve, affecting the latter in the bicipital groove. It

seems often to occur in middle-aged persons who work a good deal with their arms, and it may be associated with chronic arthritis of the elbow. For example, one of my patients was a ship's quartermaster who had spent years at the steering wheel. The typical signs of chronic ulnar palsy are sometimes seen bilaterally. The operation of anterior transplantation of the nerve, if performed early, is curative. The other form is sciatica where great and sometimes dramatic relief is obtained in obstinate cases by the epidural injection of 20 cc. of 1 per cent novocaine solution followed by 80 cc. of normal saline or by the injection of similar quantities of fluid into the nerve trunk in the buttock.

(2) *Causalgia* (see also Volume II, page 3163).

This painful condition follows partial severance of a peripheral nerve—usually the median—in injuries. *Trophic changes in the index and middle fingers occur with lividity, swelling, shiny skin, and curvature and brittleness of the nails.* Severe burning pain with exacerbations is constant. The essential in treatment is early operation with resection of the damaged part of the nerve followed by nerve suture. Unless done early neither this nor cutting the posterior nerve roots nor the spino-thalamic tracts will give relief.

(3) *Ganglion neuromata* (see also page 4273).

These are characterised by extreme tenderness to touch of an old scar. The affected nerves should be exposed, stripped for some distance, and severed as far as possible above the neuromata. The ends of the nerves should be ligatured and injected with absolute alcohol.

CHAPTER V

Abnormalities of Muscular Power and Tonus

There are many conditions of disability capable of amelioration by surgery that are the result of partial or complete paralysis or of hypertonus or flaccidity in skeletal muscle groups. It is unnecessary to refer in detail to the operative and other surgical procedures that can be carried out, on the one hand in spastic conditions such as hemiplegia for the relief of rigidity or of pain, or, on the other hand, to counteract the effects of paralysis in patients suffering from the flaccid palsies of anterior poliomyelitis. General consideration may, however, be given to some of the medical aspects of such cases, as harm may be done or effort be wasted in misdirected treatment.

The type of patient who may be helped by the surgeon to gain some return of function is one whose spastic or flaccid paralysis is permanent but non-progressive, and whose general condition and mental state are good. Thus, rigidity may be lessened and function assisted by appropriate procedures in a child suffering from congenital hemiplegia but, clearly, such surgical intervention would be contra-indicated if the child were mentally defective. It would also be contra-indicated if the hemiplegia in a child or adult were a manifestation of a progressive disease—for example, in an adult whose paralysis was caused by hæmorrhage or thrombosis as a result of advancing cerebral arteriosclerosis. Surgical procedures may be employed in spastic paralysis for two reasons: (1) for relief of deformity and to improve function, and (2) to lessen suffering and pain. For the second of these two reasons operative procedures may at times be needed during the course of progressive conditions.

The forms of hypertonus may be grouped as follows:

(1) *Cerebral in Origin.*

(*a*) *Hemiplegia.* Hemiplegia occurring early in life, or present from birth, is often susceptible to much improvement by surgical treatment. Later in life great care is needed in eliminating the presence of progressive disease such as vascular degeneration, disseminated sclerosis, or cerebral or spinal neoplasm, which will be present in a high proportion of cases. Cerebral thrombosis with the production of hemiplegia occurs sometimes in adults free from any detectable degree of arteriosclerosis and where the outlook as regards general health is good. Such patients would be good subjects if any surgical procedure, such as tenotomy or Stoffel's operation, appeared to be indicated.

Progressive change of physical signs is, as a rule, rapid in hemiplegia secondary to a cerebral neoplasm.

(*b*) *Congenital diplegia.* This familiar condition is due to failure of development *in utero* of cortical neurones, chiefly those of the pyramidal tracts. Early in life the child's limbs are noticed to be weak and spastic. The legs are usually hypertonic in extension, and adduction spasm (scissor legs) is common. The

syndrome varies in severity from one of complete powerlessness in all limbs to the slightest of disabilities. Even in the worst cases, intelligence may be good, but in others the neurones of the association areas are affected and mental defect is present. The expectation of life is much shortened in severe cases, when death usually occurs in early adult life. This point, together with the state of the child's intelligence, should be borne in mind when considering palliative surgical procedures such as tenotomy, Stoffel's operation, etc. In a case with a moderate degree of disability, much improvement may be obtained under such treatment, but in more severely affected cases where painful muscular spasms occur, relief from suffering may be given by tenotomy or total division of motor nerves, although no increase in function can be expected

In certain cases of diplegia, marked involuntary movements of an athetochoreiform character are to be seen These may be associated with spasticity or may occur in its absence. They are produced by failure of development of corpus striatum neurones, especially those of the putamen.

(c) *Extra-pyramidal rigidity.* The rigidity and contractures of post-encephalitic Parkinsonism may be helped by surgical intervention. For example, tenotomy of the tendo Achillis may enable a patient to walk unaided when he had previously been unable to do so. Post-encephalitic cases, however, are not always stationary. In a moderate proportion of Parkinsonians, the condition is steadily progressive and the benefit from any orthopædic treatment may be very temporary. Post-encephalitic Parkinsonism must be differentiated from paralysis agitans, which, as a rule, develops at an age which would of itself often contra-indicate surgical treatment and which is, in addition, progressive.

(2) *Due to Spinal Cord Lesions.*

The two forms of spastic paraplegia, that in extension and that in flexion, may, when in a chronic stage and apparently non-progressive, be considered with a view to ameliorative surgical treatment. Paraplegia in extension may be helped by tenotomy of the tendo Achillis, Stoffel's operation, etc., but much care is needed in selecting suitable cases owing to the high proportion which are due to progressive disease. One would mention paraplegia in flexion as a condition in which surgery can give great relief from suffering, although no improvement in function can be expected. Patients with this form of paraplegia experience great pain from frequent flexor spasms of the legs and they become completely bed-ridden owing to their distorted postures. In advanced cases the knees will be flexed on to the abdomen and the legs strongly adducted. By suitable procedures of tenotomy and division of motor nerves, the spasms may be abolished, pain caused to disappear, and the awkward position of the legs corrected. I have seen a patient—a professional man—bed-ridden and in suffering for a year, able to resume his work sitting in a chair, after suitable surgical treatment.

(3) *Due to Lesions of Peripheral Motor Neurones.*

The most important form of peripheral or flaccid paralysis with muscular wasting as far as surgical treatment of the resulting disabilities is concerned is *acute anterior poliomyelitis.* So many cases suitable for surgical help are seen because the disease is common in the young and, with survival from the acute attack, the condition is non-progressive.

The treatment of the paralysed muscles after the acute attack, during the period prior to attempting any surgical procedures to diminish disability, need not

be described here. The disease, however, needs discrimination from the primary muscular degenerations of childhood—the myopathies. A family history will often be obtainable of the latter. There will be no history of acute onset, and the wasting will be symmetrical and most marked around the pectoral and pelvic girdles. The pouting myopathic facies may be observable, as may be pseudo-hypertrophy of some of the muscles. A similar syndrome, which is, however, not a myopathy but a degeneration of lower motor neurones, is peroneal muscle atrophy. This condition becomes stationary after some years, when paralysis has reached not higher than the lower third of the thighs and the lower third of the upper arm muscles. When this final stationary condition is reached, palliative orthopædic procedures on the legs may be carried out to improve gait.

In the muscular wasting and spastic palsies that are so familiar in motor neurone disease (progressive muscular atrophy and amyotrophic lateral sclerosis), and in syringomyelia, no surgical palliation is possible, owing to the progressive nature of the diseases. This is especially true of the former, but an occasional case of syringomyelia becomes stationary or progresses with extreme slowness. Care should be taken in middle-aged patients not to misdiagnose peroneal muscular atrophy as progressive muscular atrophy. The stationary character of the former, with its characteristic distribution of atrophy and its family history, will differentiate it.

Reference has already been made, on page 5522, to the surgical treatment of interstitial neuritis.

CHAPTER VI

Coma and Delirium

(A) *Unconsciousness.*

This may be partial or complete. *Partial unconsciousness* often takes a characteristic form: the patient appears on inspection to be completely unconscious, lying still with closed eyes, oblivious of his surroundings, but capable, to a degree that is surprising, of being roused to answer questions. Such questions may be well answered, only to be followed by immediate relapse into the previous condition. Patients may also be roused from this state by the application of painful stimulation, such as pressure on the supra-orbital nerves in the supra-orbital notch, tweaking the nose, etc. These stimuli may prove that a patient who cannot be made to answer questions is nevertheless only lightly unconscious. Appearances are deceptive, and without these trials the mistake of concluding that a partially or lightly unconscious patient is deeply in coma can easily be made. Concussion following a blow on the head is characterised by this type of light unconsciousness. Associated with it in this condition is a lowering of all vital processes—the pulse is thready, respiration shallow, blood-pressure and temperature sub-normal, and the skin pale. The unconsciousness is probably due to a general anæmia of the cerebral cortex due to the fall in blood-pressure—the latter being a result of shock to the medullary centres.

A very similar impairment of consciousness was seen during the "lethargic" stage of an acute attack of encephalitis lethargica. It must be remembered that acute attacks of this disease, especially with lethargic symptoms, are to-day of very rare occurrence.

In the state of light unconsciousness the reflexes are present and of normal type. A state of apparent unconsciousness may be seen in hysteria. Here strong resistance may be made to attempts at rousing. This must be distinguished from a similar resentment shown by patients with cerebral irritation following head injury.

It must be remembered that light unconsciousness may be the early stage of what later progresses into deep coma, or it may be a stage of recovery from the latter. Therefore, it is highly important that patients showing this symptom should be placed under constant observation, and if the cause of the condition is not clear any investigation necessary to make a diagnosis should be undertaken at once. This may enable such conditions as a middle meningeal hæmorrhage or diabetic coma to be treated in the earliest stages. Partial unconsciousness where the cause is not clear should never be taken lightly.

In *complete unconsciousness* or *coma* the patient cannot be roused to answer questions and is irresponsive to painful stimuli. Such reflexes as the corneal response and the pupillary reaction to light are absent. The plantar response may be extensor, the vital processes may be sub-normal, as in concussion, or the pulse may be slow and full. Breathing may also be shallow or, in certain conditions, deep and stertorous.

Differential Diagnosis of Coma.

(1) *Injury.* A blow on the head. Diagnosable from the history. Examine the scalp for signs of an injury when a history is unobtainable. Coma may be due to severe concussion or to compression of the brain from a depressed fracture or from intra-cranial hæmorrhage. Deepening unconsciousness with focal signs such as hemiplegia may be signs of the latter. In meningeal hæmorrhage an enlarged pupil may be seen on the side of the hæmorrhage. Paralysis of limbs may be detected by passive movement of them, when absence of tone will be appreciated on the paralysed side.

(2) *Post-epileptic Coma.* Confirmed by obtaining a history of previous epileptic attacks. In the absence of history, the epileptic facies may be observed and scars from previous falls may be seen.

(3) *Diabetic Coma.* History of diabetes. Smell of acetone in the breath. Presence in the urine of sugar and acetone—the latter in large quantities giving a positive ferric chloride test. In all such cases where the cause of coma is not readily found by clinical examination the urine should be examined for sugar, acetone, albumen and casts, a specimen being obtained by catheterisation. Low intra-ocular tension and air hunger may also be seen in diabetic coma.

(4) *Hypoglycæmic Coma.* As this only occurs in a patient under treatment with insulin it will be suspected from this history. Sudden onset with absence of acetone and aceto-acetic acid from the urine, if not of sugar also, will differentiate it from diabetic coma.

(5) *Uræmia.* Again, a clue may be obtained from the history. The breath may smell urinous, and the urine will be of low specific gravity and will contain albumen and casts. The blood-pressure may be raised above normal. Epileptiform convulsions may occur and focal signs, such as hemiplegia, may be seen.

(6) *Cholæmia.* A typhoidal state deepening into coma is characteristic of this condition which is a form of acute and commonly fatal toxæmia that terminates acute yellow atrophy of the liver and which may be seen in hepatic cirrhosis (without jaundice) and in some cases of toxic or infective jaundice. It is possibly due to loss of the detoxifying action of the liver cells. Bile, albumen and casts are likely to be found in the urine, with a high percentage of ammonia-nitrogen and with amino-acids such as leucine and tyrosine in excess. The patient, except in portal cirrhosis, will probably be jaundiced and febrile.

(7) *Acute General Infections and Toxæmias.* Coma may occur in the late stages of septicæmia. Evidence of general infection will make this diagnosis easy.

Meningitis has already been described on page 5484.

(8) *Drugs.* Due to toxic doses of cerebral depressants. Readers will remember the classic danger of mistaking some other cause of coma for unconsciousness which is due to alcohol, owing to the smell of it in the patient's breath when it happens to have been given previously in an attempt to revive the patient. Morphia and opium show pin-point pupils and shallow respiration with, sometimes, a characteristic smell on washing out the stomach. Poisoning with veronal may be accompanied by cyanosis and signs of cardiac failure. A history of drug addiction or of suicidal tendencies may help in diagnosis, as well as analysis of stomach contents after washing out the stomach. This procedure should always be carried out if there is any suspicion of poisoning as a cause. Occasionally, the organic arsenicals may produce an acute arsenical encephalitis with convulsion,

coma, and rapid death. Lead poisoning may be manifested as a general acute cerebral toxæmia in acute lead encephalopathy, a condition associated with delirium and convulsions, leading to coma. A raised protein content with lymphocytosis may be found in the cerebro-spinal fluid.

(9) *Cardio-vascular Disorders.* Coma results in these conditions through the production of cerebral anæmia. This may be due to severe hæmorrhage or acute cardiac failure, and sometimes in sub-acute or chronic cardiac failure—the latter a common cause in middle-aged or elderly people and often misdiagnosed. It occurs in patients suffering from cerebral arteriosclerosis whose heart muscle begins to weaken as a result of coronary atheroma. It does not appear to develop, except as a terminal event, when cerebral arteriosclerosis is absent, and cases of the latter that develop it usually show as the precipitating cause some degree of myocardial failure. I have seen a patient completely unconscious from this cause for as long as nine weeks before death. Focal cerebral vascular lesions are also a common cause of coma in middle-aged and elderly people. These are cerebral thrombosis and hæmorrhage, which we have already described. Cerebral embolism, dependent upon some cause elsewhere, may obviously occur at any age when such causes are operative. Subarachnoid hæmorrhage from a ruptured congenital cerebral aneurysm and pachymeningitis superior hæmorrhagica must be remembered as less common causes. The convulsions followed by unconsciousness of the Stokes-Adams' syndrome are due to anæmia of the brain.

(10) *Other Diseases of the Brain.*

(*a*) *Acute encephalitis.* Acute disseminated encephalomyelitis, occurring spontaneously or associated with an acute specific fever and, rarely to-day, the late stage of acute encephalitis lethargica. Fever, slight meningitic signs, and normal cerebro-spinal fluid, or fluid containing only slight excess of cells and protein, and signs of involvement of the mid-brain, such as strabismus and ptosis, will help in diagnosis.

(*b*) *Cerebral tumours and abscesses* Here coma is generally due to a rise in intra-cranial tension, signs of which, such as papillœdema, will be found. It may result from extensive involvement of the frontal lobes, especially the left frontal, by the growth. Three conditions—acute encephalitis (both forms), frontal tumour, and tuberculous meningitis—are apt to be confused with one another. The cerebro-spinal fluid in cases of tumour and abscess often shows a high rise in total protein with the presence of globulin In tumour there will be no excess of cells, but some excess of leucocytes may be found in abscess.

(*c*) *Acute hydrocephalus from various disease-processes* is an occasional cause and is apt to be overlooked. It may occur in cases of cerebral tumour, especially of the posterior fossa or of the mid-brain and third ventricle. In very acute hydrocephalus, as in intra-ventricular hæmorrhage, great simultaneous rise in pulse-rate, temperature and respiration may be seen.

(*d*) *The "congestive attacks" of general paralysis of the insane* may be followed by a period of unconsciousness as after an epileptic attack.

(*B*) *Delirium and Excitement.*

Conditions of delirium or excitement often represent a state either preceding or succeeding one of coma. For example, in epilepsy, where on recovery from an attack of grand or petit mal a period of excitement may ensue. Also, in diabetes mellitus a restless form of "coma" may be seen. The excitement of alcoholism

needs no further mention. The early stages of acute general infections or toxæmias commonly exhibit delirium to be followed later, if the condition grows worse, by unconsciousness. The unconsciousness due to cerebral anæmia from various causes has been described. This state may be preceded or succeeded by one of excitement. For example, delirium as a sign of myocardial heart failure should not be overlooked. The picture of cerebral irritation following a state of clouded consciousness due to concussion is another instance. States of excitement *may be seen in uræmia and in general paralysis of the insane.*

Delirium may be due to the manic stage of the major mental disorder of manic-depressive psychosis. No toxic or other physical cause for this condition will be discoverable. A history of exacerbations and remissions occurring at intervals of months or years, alternating in some cases with periods of depression, may be obtained. The diseases of the brain that have already been described as being liable to produce clouding of consciousness and coma *may all cause* delirium either as a symptom of oncoming coma or of recovery from the latter.

In the treatment of delirium the rapid diagnosis of its cause should be possible if the above points are borne in mind. The appropriate therapy for the underlying condition can then be administered. Often, however, the surgeon may be forced by the necessity to quieten the delirium quickly in order that the patient may be satisfactorily nursed, prevented from disturbing others, and enabled to gain much needed rest. For this purpose chloral and bromide by mouth or rectum, or morphia and hyoscine hypodermically, have long been employed. Undoubtedly now, however, more powerful and certain control—combined with safety—is obtainable with barbiturates. Somnifaine, up to 4 cc. intravenously, is almost instantaneous in inducing sleep which usually lasts for five or more hours. For a slower effect it may be given intramuscularly in similar amounts, as may also luminal in doses of up to 4 grains.

CHAPTER VII

The Nervous Patient

The problem of this type of patient to the surgeon is twofold. In the first place, the symptoms of his nervous state when superadded to the symptoms of his organic disease may complicate the diagnosis and also add to the anxieties of treatment both before and after operation. Secondly (and this aspect of the problem is perhaps apt to be overlooked), the effects, which may sometimes be deleterious, of surgical treatment upon his nervous symptoms have to be considered.

By the term "nervous patient" is meant the sufferer from minor psychological or psychoneurotic symptoms as distinct from one of the major mental disorders or psychoses. In ordinary surgical practice as distinct from that within the walls of a mental hospital the surgeon will, from time to time, come into contact with one type of these latter major mental disorders—manic-depressive psychosis. People suffering from this condition, however mildly, have a predisposition to commit suicide and often inflict injuries upon themselves with which, if they are not fatal, the surgeon is called upon to deal.

Manic-depressive psychosis is probably far and away the commonest cause of attempted suicide. In its earliest stages the psychological symptoms may be very slight and easily mistaken for a minor neurotic condition. A firmly fixed delusional feeling of hopelessness with, at times, ideas of self-blame, help in differential diagnosis. To these patients the world seems black, empty, and devoid of savour. The history shows that the attacks of depression are often periodic and that relatives have frequently suffered from the same condition.

The treatment of manic-depressive suicidal cases is not complete when recovery from the physical results of attempted self-destruction has taken place. Treatment for the mental condition should follow immediately and one efficacious form of it can be given under any conditions such as obtain in a general hospital, nursing home, etc., where skilled supervision can be exercised. This form of treatment consists of prolonged narcosis, achieved at present by the use of barbiturate drugs, whereby nearly 40 per cent of remissions can be expected.

Reverting to the "nervous patient" with psychoneurotic symptoms, a broad classification must be made in order that the problems that may face the surgeon can be appreciated. The different conditions are best arranged as follows:

(1) Nervousness in children. (2) Anxiety states. (3) Hysteria. (4) Obsessional states.

(1) Some of the signs in *the nervous child* are of great importance to the surgeon. Such children often exhibit quite severe abdominal symptoms, such as epigastric pain of a spasmodic character which may or may not be related to food or be accompanied by other dyspeptic symptoms or by vomiting. Attacks of pain may also occur in the lower abdomen, e.g., in the right iliac fossa. The diagnosis is

best made clear in such children not merely by eliminating any organic disease but, in addition, by looking for the various positive signs of nervousness. Children exhibiting these pseudo-physical symptoms are generally over-emotional and excitable. Their parents may describe them as restless and "always on the go." Sleep is frequently poor and night-terrors or fear of sleeping alone or in the dark are often present Wilfulness, bad-temper, and a tendency to become easily terrified are commonly seen It is frequently apparent that one or both of the parents are themselves of an over-emotional disposition and a family history of nervousness can be elicited in many cases. In some of these children the signs of cyclical vomiting with ketonuria may be found, when relief may be obtained by the administration of glucose 20 gms. t.d.s. Pains, of a deceptively organic character, are sometimes complained of by nervous children in other parts of the body, but abdominal symptoms are the most frequent. In fact, one of the commonest forms of abdominal pain in childhood is probably that of functional origin.

(2) The child is father to the man and the sufferer with an *anxiety state* exhibits symptoms very similar to those just described. He is characteristically restless, emotional, excitable, easily driven into a panic, and often complains of a chronic inexplicable feeling of dread and foreboding. He worries over trifles, and all the minor difficulties and trials of life are greatly exaggerated. Sleep is frequently poor One of the reasons why he is apt to be seen by the surgeon is because he is often full of hypochondriacal anxieties, when the least ache or pain may give rise to the fear of some serious underlying physical disease. Abdominal symptoms are a frequent manifestation of an anxiety state. Anorexia, dyspepsia, pain after food, or bearing no relation to food, and vomiting may be seen. Many patients with such signs have undergone laparotomies for such vague surgical entities as chronic appendicitis. Again, it must be emphasised that, in order to clarify the diagnosis completely, the surgeon should not rest content with the elimination of organic disease, but should seek positive evidence of an anxiety state which is itself just as much a pathological condition as an impacted gall-stone. As in the case of the nervous child, the family history should be enquired into. Anxiety states can roughly be divided into very chronic forms dating from early life and often with a family history, and more recent acute forms developing during adult life. As a rule, the former type has a worse prognosis and more severe symptoms. Many of these patients probably have a strong constitutional predisposition and are likely to present the surgeon with bigger problems.

Allied to the anxiety states are the conditions of nervousness in women, with similar symptoms that may appear at the climacteric or in association with disorders of menstruation earlier in life. It is in cases of anxiety states injudiciously handled that the "*chronic abdomen*" and the patient who is always seeking and welcoming another operation are seen.

Before embarking on any form of surgical treatment other than emergency procedures, especially of a major operative character on the abdomen, the patient's mentality should be summed up and the obvious signs of an anxiety state looked for. If this is found, great care should be exercised in dealing with him. Impatience is out of place—an anxiety state is not synonymous with malingering. At the same time, pandering to him and sympathising excessively with his fears may be harmful. The patient may be gaining some attention, service, and devotion to himself from those who undertake his treatment, for which he feels a psycho-

logical craving in his everyday life; and after treatment is over he may become a chronic patient in an attempt to command this attention indefinitely.

The greatest care should be taken to avoid treating a case of chronic anxiety state surgically unless this is absolutely necessary. In particular, the harm done by operating upon a case whose symptoms are purely functional and merely simulating organic disease and who is free from the latter is more than the mere physical harm of an unnecessary operation. It may start the train of prolonged hypochondriacal invalidism. Prior to embarking upon necessary surgical treatment, a patient with an anxiety state should be dealt with with a kindly but unemotional impersonality. His dreads should be understood but, without over-sympathy, should be carefully explained away and he should be reassured and an atmosphere of confident calm created. Harshness or lack of understanding, on the one hand, and emotional over-sympathy on the other, are both harmful.

Symptoms of anxiety, exaggerated by fear of impending operation, are often associated with insomnia. Much improvement may result from adequate relief of this, for which barbiturate drugs are the most useful. Potassium bromide 20 grs. t.d.s. should also be given.

The number of cases of chronic anxiety that have been made much worse by a surgical operation is large. Frequently, in studying case histories, one finds an increase in the severity of symptoms dating from such an occurrence. This risk is minimised if the steps in handling and treating such cases as have been described are carefully followed.

(3) The same régime should be followed when undertaking surgical treatment of a patient showing symptoms of *hysteria*. Two points must be emphasised. One is that the physical symptoms in hysteria may simulate surgical conditions very closely and discrimination may be extremely difficult. Hysteria can often be suspected by the patient's placid and almost contented attitude towards his symptoms. He frequently fails to exhibit the degree of normal concern that a mentally healthy patient shows towards some condition of physical disease from which he may be suffering.

The complete subject of differential diagnosis between hysteria and organic disease naturally cannot be dealt with here.

The second point to be remembered is that the hysterical patient is even more liable to become chronically dependent upon his medical attendants than is the anxiety neurotic. An example of the close simulation of an organic condition that can occur in hysteria may be given from a case under the observation of a surgical colleague. For nine years a man had suffered from a completely paralysed arm which was flail-like and had become a nuisance to him. It was decided to amputate and he was admitted to hospital. During the process of pre-operative preparation he noticed power returning to his fingers and eventually, as a result of the suggestion of these preliminaries, complete function returned.

(4) Similar treatment and precautions should be applied to patients with *obsessional neurosis*. Sufferers from this neurosis comprise those persons who become slaves to rituals such as prolonged hand-washing, or to obsessive thoughts.

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